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Survivorship, clinical outcomes and indications for revision in uncemented unicompartmental knee arthroplasty: systematic review

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Modern uncemented unicompartmental knee arthroplasty (UKA) relies on the mechanics of the implant design and a biological bond at the bone-implant interface to create a secure fixation of its components. The aim of this systematic review was to determine implant survivorship, clinical outcomes and indications for revision in uncemented UKAs. A search strategy was employed using keywords related to UKAs and uncemented fixation to identify suitable studies. Both prospective and retrospective studies with a minimum of two year mean follow-up were included. Data was gathered on study design, implant type, patient demographics, survivorship, clinical outcome scores and the indications for revision. Methodological quality was assessed using a ten-point risk of bias scoring tool. Eighteen studies were included in the final review. The mean follow-up of studies ranged between 2-11 years. The primary outcome of survival demonstrated 5 year survivorship ranged between 91.7-100.0% and 10-year survivorship between 91.0-97.5%. Clinical and functional outcome scores were found to be excellent in the majority of studies with the remaining reporting good results. Revisions represented 2.7% of the total operations performed. There were 145 revisions with an overall revision rate of 0.8 per 100 observed component years. Osteoarthritis disease progression (30.2%) and bearing dislocations (23.8%) were the most common causes of implant failure. This review finds uncemented UKAs demonstrate comparable survivorship, clinical outcomes and safety profile to cemented UKAs to consider this fixation a suitable alternative in clinical use.

Keywords: unicondylar knee arthroplasty; UKA, knee.

INTRODUCTION

Unicompartmental knee arthroplasty (UKA) is an established treatment for isolated compartment knee osteoarthritis. The most common compartment affected is the medial side[1,2]. This implant conventionally uses cement fixation for its components. However, there is a growing body of literature regarding uncemented fixation.

The latest report from the National Joint Registry for England, Wales, Northern Ireland and Isle of Man demonstrates UKAs account for approximately 11.1% of all primary knee arthroplasty surgery[3]. The incidence of UKA surgery has been increasing each year for the last five years, although the exact proportion that are uncemented is not detailed[3]. Nonetheless, popularity of uncemented fixation has been evidenced in the New Zealand Joint Registry, where it accounts for highest proportion of UKA surgery performed[4].

UKA has been a treatment modality for osteoarthritis since the 1970s[5]. For isolated compartment knee osteoarthritis, the cemented Oxford UKA has been in use since 1982 and an uncemented implant since 2003[6]. Early generations of uncemented UKAs, such as the porous coated anatomic (PCA) unicompartmental knee replacement have been contentious in their use, with poorer reported outcomes and high failure rates[7]. In light of this, there has been historically reduced approval and uptake of uncemented fixation compared to its cemented counterpart. However, development of newer designs and more modern implants indicating comparable implant survival and clinical outcomes supports the enthusiasm around the use of uncemented UKAs[7-24].

Drawing comparison to TKA implants, early generations of uncemented prostheses such as the press fit Kinemax (Stryker ™ Howmedica Osteonics, Allendale, New Jersey, United States of America) TKA and PCA TKA witnessed high rates of revision for

loosening, with failure of the implant to bond at the bone-prosthesis interface[25,26]. However, recent meta-analysis suggests modern uncemented TKAs now have similar functional outcomes and potentially greater all cause survivorship than cemented fixation[27]. In part, this can be attributed to improvements in porous surface coating with hydroxyapatite for greater biological osseointegration, it is plausible for modern uncemented UKAs to follow a similar trend to the progress made in uncemented TKA generations[29].

Moreover, uncemented unicompartmental knee replacements stipulate their benefits through potential reduction in operating time, absence of the cementation process and its negative sequelae if inefficient or inductive of tissue reaction[28,29]. In addition, the incidence of radiolucent lines (RLLs) bordering the prosthesis are lower in uncemented UKAs compared to cemented UKAs, which supports the current rationale of greater biological ingrowth between bone and implant[30]. In emerging arthroplasty technology, the use of navigation systems in computer or robotic assisted surgery aim to improve procedural precision planning and execution, which can confer further benefit to uncemented fixation through increased accuracy in bone cuts and implant positioning[31].

The aim of this study is to perform a systematic review of the literature on uncemented unicompartmental knee replacements. The primary objective is to report the survivorship of these implants. The secondary objectives are to report the clinical outcome scores and indications for revision surgery identified in the collated studies.

METHODS

This systematic review was performed by two independent reviewers (A.P. and A.V.) using a search strategy identified in Figure 1, the search strategy was used to comprehensively identify studies in English language from four databases (PubMed, MEDLINE, EMBASE and Cochrane). This study has been registered with the PROSPERO register of systematic reviews with registration date of the 5th of June 2020 and protocol number CRD42020179940. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) framework was followed to produce the included studies in this review, the last search performed was on the 20th of June 2020 to ensure all recently published articles were included.

The studies were required to meet the following criteria in order to be included; all articles must report on the primary outcome of implant survivorship, and

Title and Abstract

("Unicompartmental knee replacement" OR "Unicompartmental knee arthroplasty" OR "Partial knee replacement" OR "Partial knee arthroplasty" OR "UKA" OR "unicondylar")

AND

("Cementless" OR "Uncemented")

Figure 1. — Search strategy.

at least one of the following secondary outcomes of a validated scoring system; clinical outcome of the uncemented UKA or indications of revision for uncemented UKA in the study group. Any reported new interventions, such as the addition or exchange of components to the primary arthroplasty procedure were termed revisions. Furthermore, each study was required to have a mean follow-up of at least 2 years. Studies published before the year 2000 were excluded. Case reports, letters to the editor, technical tips, cadaveric, animal, studies on older implant designs (e.g. PCA) and biomechanical studies were all excluded. Studies that failed to report on survivorship of the implant or at least one of the secondary outcomes of revision or clinical outcome clearly were also excluded from this review.

Both independent reviewers (A.P. and A.V.) extracted the data through the search strategy identified in Figure 1 for the primary objective of survivorship and the secondary objectives of clinical outcome and revision in this study. Any discrepancy between authors was referred to the senior author for final arbitration.

For each respective study, data has been extracted with regards to the study design, implant type, number of cases, mean follow-up and patient demographics such as mean age and male: female ratio. For the objectives of this systematic review, data was gathered for reported overall or cumulative survivorship, clinical outcomes through validated scoring systems such as Oxford Knee Score (OKS), objective and functional Knee Society Score (KSS), International Knee Society (IKS) score, and the number and indications of revision surgery. Studies were grouped according to their 5 year and 10-year survivorship. Clinical outcome scores were assessed according to a category grading scale as priorly used in the literature[32,33]. Non-weighted mean and range calculations were performed. Revision rates have been expressed as revisions per 100 observed component years, in order to compare between individual studies of various follow-up periods, the

Table 1. — Risk of bias assessment, adapted tool [35].

Question	Response
1. A clearly stated aim.	Did the authors have a 'study question' or 'main aim' or 'objective'? The study question should be precise and relevant to available literature, and to be scored adequate the aim should be coherent with the 'Introduction' of the paper.
2. Inclusion of consecutive patients.	Did the authors have 'consecutive patients' or 'all patients during period from...to...' or 'all patients fulfilling the inclusion criteria'?
3. A description of inclusion and exclusion criteria.	Did the authors report the inclusion and exclusion criteria?
4. Prospective collection of data.	Did the authors report whether 'prospective', 'retrospective' or 'follow-up'?
5. Surgical implant and technique detailed.	Did the authors include description of the surgical implant and technique?
6. Appropriate outcome measurements	Did the authors clearly report all outcome measures to evaluate patients, including pre-operative and post-operative clinical scores? Did the authors clearly report the demographic data for the patients of the study? Both questions should be positive to be scored adequate.
7. Unbiased assessment of study outcomes	Did the authors used an independent method in data collection and assessment of outcomes?
8. Appropriate follow-up period	Did the study have an appropriate two year follow-up period?
9. Loss of follow-up reported	Did the authors report the losses to follow-up?
10. Adequate statistical analysis	Did the authors perform adequate statistical analysis?

Table II. — Risk of bias assessment scores

Study	1	2	3	4	5	6	7	8	9	10	Total
Blaney et al.[7]	1	1	1	0	1	1	1	1	1	1	9
Campi et al.[8]	1	1	1	1	1	0	1	1	1	1	9
Campi et al. [9]	1	1	1	1	1	1	1	1	1	1	10
Epinette et al.[10]	1	1	0	1	1	0	0	1	1	1	7
Hall et al.[11]	1	0	0	0	1	0	0	1	1	1	5
Hooper et al.[12]	1	1	1	1	1	1	1	1	1	1	10
Jeer et al.[13]	1	1	1	0	1	1	0	1	1	1	8
Kendrick et al.[14]	1	1	1	1	1	1	0	1	1	1	9
Kerens et al.[15]	1	1	1	0	1	0	1	1	1	1	8
Lecuire et al.[16]	1	1	0	0	1	1	0	1	1	1	7
Liddle et al.[17]	1	1	1	1	1	1	1	1	1	1	10
Mohammad et al.[18]	1	1	0	1	1	1	1	1	1	1	9
Pandit et al.[19]	1	1	1	1	1	1	1	1	1	1	10
Pandit et al.[20]	1	1	1	1	1	1	1	1	1	1	10
Panzram et al.[21]	1	0	1	0	1	1	0	1	1	1	7
Panzram et al.[22]	1	1	1	0	1	1	0	1	1	1	8
Schlueter- Brust et al.[23]	1	0	1	1	1	0	1	1	1	1	8
Stempin et al.[24]	1	1	1	0	1	1	0	1	0	1	7

formula is number of revisions x 100 / number of cases x follow-up in years, consistent with previous approach in this field of study[34].

Assessment of the methodological risk of bias for the studies was performed independently by two reviewers (A.P. and M.J.), with any disputes resolved by a third reviewer (A.V. or S.K.). The assessment tool, shown in Table I, is based on a ten question risk of bias assessment index used in recently published systematic review work by authors (A.V. and S.K.)[35]. In this tool, if a question is met 1 point would be awarded, otherwise 0 points would be awarded if there

was no relevant information within the study, thereby a maximum score of ten points can be obtained. Studies to be deemed of high methodological quality had a minimum score of 6 and scored 1 point in questions 6,7 and 10. The respective scores of the studies included in this systematic review are displayed in Table II.

RESULTS

The literature search generated 167 results. In accordance with PRISMA guidelines, following identification of the 167 studies, 75 duplicates were removed, and 92 titles and abstracts were screened for eligibility according to the inclusion criteria. This yielded 18 studies, in which full texts were reviewed. All 18 studies were found to meet the inclusion criteria for this review.

All eighteen articles reported on the primary objective measure of survivorship of uncemented UKAs and provided an objective measure of clinical outcomes through a validated scoring system were detailed in 18 articles. However, one study[23] reported combined clinical outcome scores of uncemented and cemented UKAs and therefore its clinical outcome score was not included in the results. The number and indications for revision surgery was outlined in all eighteen studies, however in one study[8] the number of bearing dislocations and disease progression episodes were not specified.

Ten of the study designs[8,9,12,14,17-20,23,36] were prospective in nature and the remaining eight studies were[7,11,13,15,16,21,22,24] retrospective data. Two studies were randomised controlled trials[14,19]. Nine of the ten[8,9,12,14,17-20,36] prospective studies had consecutive patients, while seven retrospective papers had consecutive patients[13,15,16,21,22,24,37]. In two studies[11,23] the data collection method was specified.

The total uncemented UKAs in this review was 5420 cases. The mean age across 17 studies was 65.9 years, one study[23] did not record mean age for uncemented UKA patients. Of the fourteen studies where data was available[8,11-16,18-22,24,37] and 56% of patients were male and 44% were female. Mean follow-up of studies in the review ranged between 2 to 11 years.

Thirteen studies[7-9,12,14,15,17-21,22,24,34,37] reported the outcomes on Oxford (Zimmer Biomet ™, Warsaw, Indiana, United States of America) UKAs. Two studies[11,36] reported on UNIX (Stryker ™, Mahwah, New Jersey, United States of America) implants. There was one study each reporting on[13,23] on LCS (DePuy Syntheses ™, Warsaw, Indiana, United States of America) UKA implants; ALPINA (Zimmer Biomet

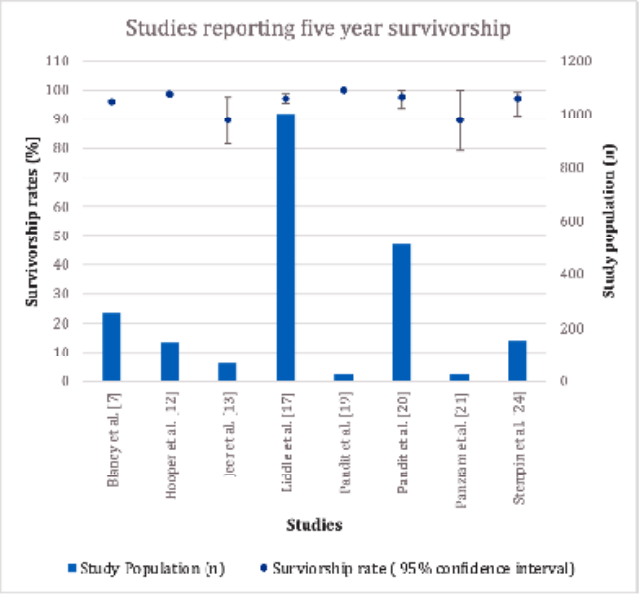

Figure 2. — PRISMA flow-diagram of systematic review.

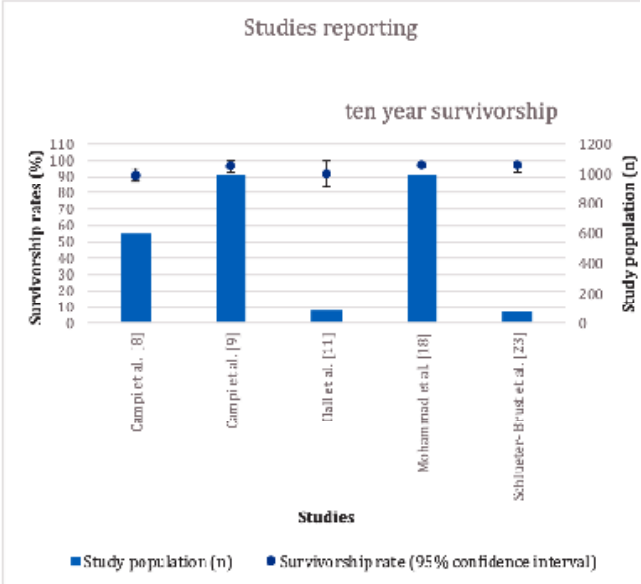

Figure 3. — Five-year survivorship of UKA implants.

France ™, Valence, Rhône-Alpes, France) implants; and[23] Uniglide (Corin ™, Cirencester, England, United Kingdom) implants.

The survivorship figures are outlined in table III, expressed either as cumulative or overall survivorship. Figure 3 demonstrates studies reporting five-year survivorship. Figure 4 demonstrates studies reporting ten-year survivorship.

Figure 3 shows eight studies[12,13,17,19-21,24,37] reported 5-year survivorship; five were overall survivorship[12,17,19,21,24] and three were cumulative survivorship[7,13,20]. The 5-year mean survivorship across all these studies was 95.8% (range 91.7% to 100%).

Table III. — Survivorship of uncemented UKAs.

Study	Study Design	Implant	Number of cases (n)	Mean age (range)	Male/ Female (n)	Mean follow-up period (years)	Overall or cumulative survivorship (rate, 95% confidence interval), {number at risk}	Revision end- point
Blaney et al.[7]	Retrospective, consecutive	OUKA	257	65 (IQR 59-73)	134/123	5.1	96% (N.R.) at 5 years {94 at risk}. Cumulative.	Any cause as end-point.
Campi et al. [8]	Prospective, consecutive case series	OUKA	598	65.0 (31-94)	341/257	2.7	91.0% (87.3-95.2) at 10 years {178 at risk}. Cumulative.	Any cause as end-point.
Campi et al.[9]	Prospective, consecutive	OUKA	1000	65.9 (35-94)	N.R.	7.0	96.8% (93.1-100) at 10 years {87 at risk}. Overall.	Any cause as end-point.
Epinette et al.[10]	Prospective, consecutive	Unix	125	69.9 (47-87)	N.R.	9.7	100% (N.R.) at 13 years {N.R. at risk}. Cumulative.	Aseptic loosening as end-point.
Hall et al.[11]	Retrospective	Unix	85	65 (60-90)	37/28	10.0	92% (83.8-100) at 10 years {34 at risk}. Overall. 76% (59.8-97.3) at 12 years {11 at risk}. Overall.	Any cause as end-point.
Hooper et al.[12]	Prospective, consecutive	OUKA	147	63.6 (39-86)	81/45	5.0	98.7%(N.R.) at 5 years {136 at risk}. Overall.	Any cause as end-point.
Jeer et al.[13]	Retrospective , consecutive	LCS UKA	66	69 (54.4-87.4)	26/26	5.9	89.7% (81.6-97.7) at 5 years {N.R. at risk }. Cumulative.	Any cause as end-point.
Kendrick et al.[14]	Randomised controlled trial	OUKA	22	67.6 (49.1-81.6)	13/9	2.0	100% at 2 years {22 at risk}. Overall.	Two year end-point.
Kerens et al.[15]	Retrospective, consecutive	OUKA	51	62.0 (45-82)	23/28	2.8	90.0% (N.R.) at 2.8 years {N.R. at risk}. Overall.	Revision with total knee replacement as end-point.
Lecuire et al.[16]	Retrospective, consecutive	ALPINA	65	71.8 (50-80)	18/47	11.0	88% (81-95) at 13 years {N.R. at risk}. Overall.	Any cause as end-point.
Liddle et al.[17]	Prospective, consecutive	OUKA	1000	66.0 (39-89)	N.R.	3.2	97.2% (95.6-98.8) at 5 years {139 at risk}. Cumulative.	Any cause as end-point.
Mohammad et al.[18]	Prospective, consecutive	OUKA	1000	66.2 (N.R.)	536/464	5.1	97.5% (95.7-98.5) at 10 years {29 at risk}. Cumulative.	Any cause as end-point.
Pandit et al.[19]	Randomised controlled trial	OUKA	30	63.8 (46-78)	16/14	5.0	100% at 5 years {28 at risk}. Overall.	Five year end-point.
Pandit et al.[20]	Prospective, consecutive	OUKA	512	65.1 (35-94)	299/221	3.4	97.6% (93.6-100) at 5 years {123 at risk}. Cumulative.	Any cause as end-point.
Panzram et al.[21]	Retrospective, cohort	OUKA	30	62.5(49-76)	15/12	5.0	89.7% (79-100) at 5 years{N.R. at risk}. Overall.	Any cause as end-point.
Panzram et al.[22]	Retrospective, cohort	OUKA	192	61.3 (36-80)	95/82	3.1	96.9% (94.4-99.3) at 3 years{N.R. at risk. Cumulative.	Any cause as end-point.
Schlueter- Brust et al.[23]	Prospective	Uniglide	78	N.R.	N.R.	10.7	97.4% (N.R.) at 10 years {N.R. at risk}. Cumulative.	Any cause as end-point.
Stempin et al. [24]	Retrospective, consecutive	OUKA	153	70.6 (54-86)	110/40	5.0	97.1% (91.1-99.9) at 5 years {N.R. at risk}. Overall.	Any cause as end-point.

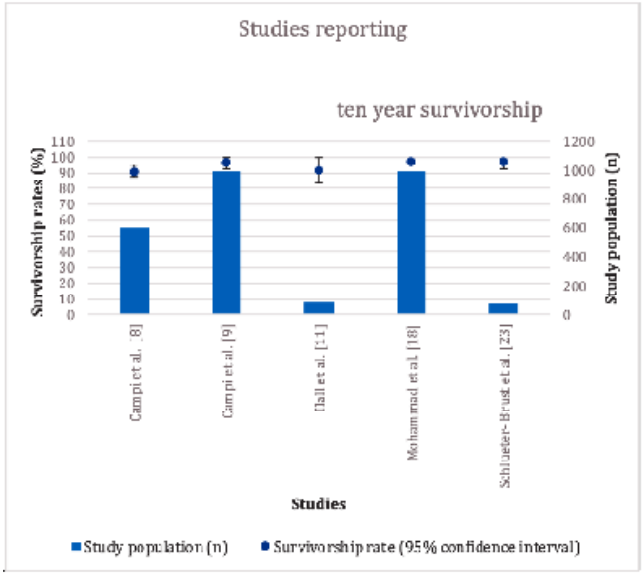

Figure 4. — Ten-year survivorship of UKA implants.

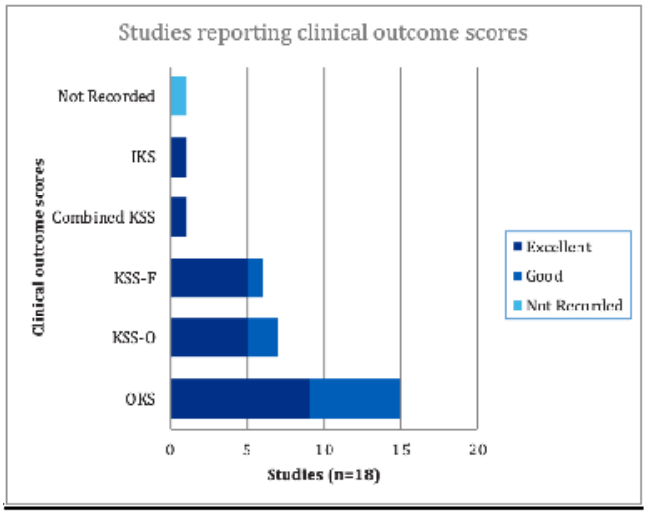

Figure 5. — Clinical outcome score grading.

Figure 4 shows five articles[8,9,11,18,23] reported a 10-year survivorship of uncemented UKAs, two were overall[9,11] and three were cumulative[8,18,23]. The ten year mean survivorship of these studies was 94.9% (range 91% to 97.5%).

Three studies[11,16,36] reported survivorship data for a greater than 10-year survival period. Of these, two studies[16,36] reported implant survivorship at 13 years, Epinette et al.[36] (100% overall survivorship) with aseptic loosening as end-point and Lecuire et al.[16] (88% overall survivorship) with revision for any cause as end-point. Hall et al.[11] determined overall 12-year survivorship using revision for any cause as end-point was 76% in Unix uncemented UKAs. Short term survival of 2, 2.8 and 3 years were reported by Kendrick et al.[14] (100% overall survivorship), Panzram et al.[22]. (96.9% cumulative survivorship) and Kerens et al.[15] (90% overall survivorship) respectively.

Fourteen studies[8,9,11-13,16-18,20-24,37] utilised revision for any cause as an end-point for survivorship. The two randomised controlled trials[14,19] reported survivorship at two years and five years, respectively. One study[36] used aseptic loosening as an end-point. One study[15] used conversion to TKA as an end-point.

The UKA clinical outcome scores in seventeen studies[7-22,24] were included. The OKS figures are expressed in table IV. Objective KSS in table V. Functional KSS, combined KSS and IKS in table VI. Figure 5 demonstrates the category grading scale of the clinical outcome scores of the studies.

Fifteen[8,9,11-15,17-22,24,37] studies reported OKS outcomes; nine[8,9,12,14,17,18,20-22] reported an excellent mean OKS and six[7,11,13,15,19,24] reported a good mean OKS outcome. The overall mean OKS was 40.3, range of 37-43.

Table V: Clinical Outcome: KSS-Objective (KSS-O) studies uncemented UKAs

Seven studies[15,18-22,24] reported on objective KSS; five recorded[18,20,21,22,24] excellent outcome and two[15,16] reported good outcome. The overall mean KSS-O was 84.7, range of 76-92.7.

Six[18-22,24] studies reported functional KSS; five studies[18-22] correlated excellent outcome and one study[24] reported good outcome. The overall mean KSS-F was 84.8, range of 76.3-92. One study[16] reported KSS as a combined objective and functional measurement and one study (36) reported an IKS score, both recorded excellent outcomes.

The category grading scale demonstrates most studies reported excellent outcome scores and no study had less than a good outcome, indicating a high proportion of patients experienced subjective and functional clinical improvement with uncemented UKA surgery.

All eighteen studies reported on the number and indications for revision in uncemented UKAs, as outlined in table 7. There were 145 revisions in 5420 cases. Mean revision per 100 components was 0.8 (range 0-3), see table VIII.

The highest proportion of revision surgery in these patients was for osteoarthritis disease progression (30.2%) this is excluding the study by Campi et al.[8] who did not specify the number of patients with disease progression. Bearing dislocation (23.8%) was the second most common indication for revision, similarly excluding (8) due to unspecified number of patients with bearing dislocations. Sixteen revision cases (11%) were for fractures, which largely affected the tibial plateau. Ten (6.9%) patients underwent revision for component

Table IV. — Clinical Outcome: OKS studies uncemented UKAs

Study	Study Design	Implant	Number of cases (n)	Mean age (range)	Male/Female (n)	Mean follow-up period (years)	Pre-operative OKS (SD, range)	Post-operative OKS(SD, range)
Blaney et al.[7]	Retrospective, consecutive	OUKA	257	65 (IQR 59-73)	134/123	5.1	16 (N.R, IQR 13-19).	37 (N.R., IQR 27-42)
Campi et al.[8]	Prospective, consecutive case series	OUKA	598	65.0 (31-94)	341/257	2.7	22.0 (8.1, N.R.)	40.0 (7.9, N.R.)
Campi et al.[9]	Prospective, consecutive	OUKA	1000	65.9 (35-94)	N.R.	7.0	23.2 (7.9, N.R.)	41.7 (6.8, N.R.)
Hall et al.[11]	Retrospective	Unix	85	65 (60-90)	37/28	10.0	N.R.	38 (N.R., 13-48)
Hooper et al.[12]	Prospective, consecutive	OUKA	147	63.6 (39-86)	81/45	5.0	22.9 (8.4, 2-44)	42.4 (6.5, 18-48)
Jeer et al.[13]	Retrospective , consecutive	LCS UKA	66	69 (54.4-87.4)	26/26	5.9	20.5 (N.R., 13-32)	37.0 (N.R., 17-48)
Kendrick et al.[14]	Randomised controlled trial	OUKA	22	67.6 (49.1-81.6)	13/9	2.0	23.7(N.R., 12-36)	41.5 (N.R., 24-48)
Kerens et al.[15]	Retrospective, consecutive	OUKA	60	62.0 (45-82)	23/28	2.8	N.R.	39.0 (N.R., 10-48)
Liddle et al. [17]	Prospective, consecutive	OUKA	1000	66.0 (39-89)	N.R.	3.2	20.9 (7.8, N.R.)	41.5 (6.7, N.R.)
Mohammad et al.[18]	Prospective, consecutive	OUKA	1000	66.2 (N.R.)	536/464	5.1	25.1(8.5, IQR 12)	41.2(9.8, IQR 6)
Pandit et al.[19]	Randomised controlled trial	OUKA	30	63.8 (46-78)	16/14	5.0	21.1 (6.1, N.R.)	39.4 (9.9, N.R.)
Pandit et al.[20]	Prospective, consecutive	OUKA	512	65.1 (35-94)	299/221	3.4	27 (9, N.R.)	43 (7, N.R.)
Panzram et al.[21]	Retrospective, cohort	OUKA	30	62.5(49-76)	15/12	5.0	27.2 (6.4, N.R.)	42.1(7.6, N.R.)
Panzram et al.[22]	Retrospective, cohort	OUKA	192	61.3 (36-80)	95/82	3.1	27.9 (7.2, IQR 23-33)	42.3 (5.9, IQR 41-46.8)
Stempin et al.[24]	Retrospective, consecutive	OUKA	153	70.6 (54-86)	110/40	5.0	15.1 (2.9, 11-22)	38.3(3.9, 24-46)

Table V. — Outcome scores for studies using the Knee society score

Study	Study Design	Implant	Number of cases (n)	Mean age (range)	Male/ Female (n)	Mean follow-up period (years)	Pre-operative KSS-O (SD, range)	Post-operative KSS-O (SD, range)
Kerens et al.[15]	Retrospective, consecutive	OUKA	60	62.0 (45-82)	23/28	2.8	N.R.	76.0 (N.R., 51-100)
Mohammad et al.[18]	Prospective, consecutive	OUKA	1000	66.2 (N.R.)	536/464	5.1	60.2(15.4, IQR 21)	89.1 (13.0, IQR7)
Pandit et al.[19]	Randomised controlled trial	OUKA	30	63.8 (46-78)	16/14	5.0	41.6 (11.1,N.R.)	78.8 (14.0,N.R.)
Pandit et al.[20]	Prospective, consecutive	OUKA	512	65.1 (35-94)	299/221	3.4	52 (20, N. R.)	81 (13, N.R.)
Panzram et al.[21]	Retrospective, cohort	OUKA	30	62.5 (49-76)	15/12	5.0	50.7 (13.3, N.R.)	92.7 (10.7, N.R.)
Panzram et al.[22]	Retrospective, cohort	OUKA	192	61.3 (36-80)	95/82	3.1	50.4 (12.6, IQR 41-57)	89.7 (12.8, IQR 86-99)
Stempin et al.[24]	Retrospective, consecutive	OUKA	153	70.6 (54-86)	110/40	5.0	35.2 (13.6, 8-38)	85.9(8.6, 84.5-87.3)

Table VI. — Clinical Outcome: KSS-Functional (KSS-F), combined KSS, IKS studies uncemented UKAs

Study	Study Design	Implant	Number of cases (n)	Mean age (range)	Male/ Female (n)	Mean follow-up period (years)	Pre-operative Functional Outcome Score (SD, range)	Post-operative Functional Outcome Score (SD, range)
Epinette et al.[36]	Prospective, consecutive	Unix	125	69.9 (47-87)	N.R.	9.7	IKS N.R.	IKS 97.9 (N.R., 77-100)
Lecuire et al.[16]	Retrospective, consecutive	ALPINA	65	71.8 (50-80)	18/47	11.0	Combined KSS 119.3 (16.8, N.R.)	Combined KSS 171.4 (25.3, N.R.)
Mohammad et al.[18]	Prospective, consecutive	OUKA	1000	66.2 (N.R.)	536/464	5.1	KSS-F 70.8 (16.8,IQR 20)	KSS-F 80.4 (14.6,IQR 20)
Pandit et al.[19]	Randomised controlled trial	OUKA	30	63.8 (46-78)	16/14	5.0	KSS-F 60.3 (13.8,N.R.)	KSS-F 92.0 (12.7,N.R.)
Pandit et al.[20]	Prospective, consecutive	OUKA	512	65.1 (35-94)	299/221	3.4	KSS-F 71 (17, N.R.)	KSS-F 86 (16, N.R.)
Panzram et al.[21]	Retrospective, cohort	OUKA	30	62.5 (49-76)	15/12	5.0	KSS-F 55 (N.R., N.R.)	KSS-F 85 (N.R., N.R.)
Panzram et al.[22]	Retrospective, cohort	OUKA	192	61.3 (36-80)	95/82	3.1	KSS- F 60.7 (19.8, IQR 50-70)	KSS-F 9.3 (15.0, IQR 80-100)
Stempin et al.[24]	Retrospective, consecutive	OUKA	153	70.6 (54-86)	110/40	5.0	KSS-F 33.2 (10.6, 5-50)	KSS-F 76.3 (12.4, 15-100)

loosening, eleven (7.6%) cases for persistent knee pain and eight (5.5%) had revision for infection.

DISCUSSION

This systematic review reports on the survivorship, clinical outcomes, and revision profile of uncemented unicompartmental knee replacements.

Eighteen studies recorded the primary outcome of survivorship in uncemented UKAs in this review. Survivorship rates of 91.7-100% at 5 years and 91-97.5% at 10 years were demonstrated. Drawing on comparisons to registry data, evidence suggests survivorship of uncemented UKAs is on par with cemented UKAs. Mohammed et al.[38] undertook a 10-year comparative review of joint registry data from England, Wales, Northern Ireland and the Isle of Man, comparing 7407 uncemented and 7407 cemented UKA implants, survivorship rates of 93% and 90% respectively were described. The survivorship difference between the two groups was shown to be significant (p=0.002). In addition, Mohammed et

Table VII. — Number and indications for revision uncemented UKAs

Study	Study Design	Implant	Number of cases (n)	Mean follow-up period (years)	Number of revisions (n)	Indications for revision
Blaney et al.[37]	Retrospective, consecutive	OUKA	257	5.1	7	3 disease progression, 2 infec-tions, 1 bearing dislocation, 1 ongoing pain.
Campi et al.[8]	Prospective, consecutive case series	OUKA	598	2.7	19	6 tibial plateau fractures, 1 sub-sidence, 1 inflammatory arthritis, 1 lateral osteonecrosis, 1 bearing subluxation and impingement, 1 unexplained pain. Disease pro-gression unspecified, bearing dislocation unspecified.
Campi et al.[9]	Prospective, consecutive	OUKA	1000	7.0	25	9 disease progression, 6 bearing dislocations, 4 unknown patho-logy, 2 tibial plateau fractures, 2 persistent pain, 1 tibial component loose, 1 tibial component overhanging.
Epinette et al.[36]	Prospective, consecutive	Unix	125	9.7	2	2 ACL deficiency and wear.
Hall et al. [11]	Retrospective	Unix	85	10.0	7	4 aseptic loosening, 2 disease pro-gression,1 infection.
Hooper et al.[12]	Prospective, consecutive	OUKA	147	5.0	6	2 bearing dislocation, 2 rheumatoid disease development, 1 disease progression, 1 tibial component loosening.
Jeer et al.[13]	Retrospective , consecutive	LCS UKA	66	5.9	6	2 disease progression, 2 ongoing pain, 1 tibial plateau fracture, 1 tibial component loosening.
Kendrick et al.[14]	Randomised controlled trial	OUKA	22	2.0	0	Nil revisions.
Kerens et al.[15]	Retrospective, consecutive	OUKA	60	2.8	5	2 unexplained pain, 1 tibial component loosening, 1 periprosthetic tibial fracture, 1 inflammatory arthropathy.
Lecuire et al.[16]	Retrospective, consecutive	ALPINA	65	11.0	11	4 polyethylene wear, 3 polyethylene fractures, 2 disease progression,1 ACL rupture, 1 unexplained pain.
Liddle et al.[17]	Prospective, consecutive	OUKA	1000	3.2	19	6 disease progression, 6 bearing dislocations, 4 fractures, 3 in-fection.
Mohammad et al. [18]	Prospective, consecutive	OUKA	1000	5.1	18	7 bearing dislocations, 4 disease progression, 2 pain, 2 infections, 1 tibial plateau fracture, 1 femoral component loosening ,1 avascular necrosis.
Pandit et al.[19]	Randomised controlled trial	OUKA	30	5.0	0	Nil revisions.
Pandit et al.[20]	Prospective, consecutive	OUKA	512	3.4	6	4 disease progression, 2 bearing dislocations.
Panzram et al.[21]	Retrospective, cohort	OUKA	30	5.0	3	1 disease progression , 1 bearing dislocation, 1 tibial plateau fracture.
Panzram et al.[22]	Retrospective, cohort	OUKA	192	3.1	6	3 disease progression, 2 bearing dislocation, 1 persistent pain.
Schlueter-Brust et al.[23]	Prospective	Uniglide	78	10.7	2	1 bearing dislocation, 1 aseptic loosening.
Stempin et al.[24]q	Retrospective, consecutive	OUKA	153	5.0	3	2 bearing dislocations, 1 disease progression.

Table VIII. — Revisions per 100 observed component years for uncemented UKAs.

Study	Implant	Number of cases (n)	Mean follow-up period (years)	Number of revisions (n)	Observed component years	Revisions per 100 observed component years
Blaney et al.[37]	OUKA	257	5.1	7	1311	0.5
Campi et al.[8]	OUKA	598	2.7	19	1615	1.2
Campi et al.[9]	OUKA	1000	7.0	25	7000	0.4
Epinette et al.[36]	Unix	125	9.7	2	1213	0.2
Hall et al.[11]	Unix	85	10.0	7	850	0.8
Hooper et al.[12]	OUKA	147	5.0	6	735	0.8
Jeer et al.[13]	LCS UKA	66	5.9	6	389	1.5
Kendrick et al.[14]	OUKA	22	2.0	0	44	0.0
Kerens et al.[15]	OUKA	60	2.8	5	168	3.0
Lecuire et al.[16]	ALPINA	65	11.0	11	715	1.5
Liddle et al.[17]	OUKA	1000	3.2	19	3200	0.6
Mohammad et al.[18]	OUKA	1000	5.1	18	5100	0.4
Pandit et al.[19]	OUKA	30	5.0	0	150	0.0
Pandit et al.[20]	OUKA	512	3.4	6	1741	0.3
Panzram et al.[21]	OUKA	30	5.0	3	150	2.0
Panzram et al.[22]	OUKA	192	3.1	6	595	1.0
Schlueter- Brust et al.[23]	Uniglide	78	10.7	2	835	0.2
Stempin et al.[24]	OUKA	153	5.0	3	765	0.4
Total		5420		145	26575	0.8

al.[39] further highlighted the importance of surgeon experience with uncemented UKAs as a significant factor in implant survivorship. Sub-analysis of the registry data accounting for surgeon caseload identified surgeons categorised as high volume, performing at least and greater than 30 cases per year, exhibited 97.5% 10-year survivorship.

Clinical outcome scores consistently exhibited positive results throughout this review. The OKS and KSS grading scales were classed as excellent in most studies, with the remaining studies reporting good results. In corresponding work related to patient clinical function, Panzram et al.[28] performed a retrospective cohort study in 27 patients who underwent a medial compartment cementless OUKA, and found patients made a rapid functional recovery to activity post-surgery. The study demonstrated 100% return to sport rate overall, 89% within 6 months of surgery[28]. Panzram et al.[28] followed this work up in 2020, with a larger retrospective study of 228 knees, which demonstrated an overall return to activity rate of 93% in patients.

This review reports revisions accounted for 2.7% of total uncemented UKA operations performed, 145 revisions in 5420 cases. Consistent with previous work on uncemented UKAs[34], the overall calculated revision rate per 100 observed component years is 0.8, with a range of 0 to 3 demonstrated in this study. This is a comparable statistic to the current nineteen-year report from the New Zealand joint registry[4], which shows a rate of 1.40 per 100 observed component years from 4,139 Oxford cemented Phase 3 implants and a rate of 0.77 from 4,616 Oxford uncemented Phase 3 implants. These revision data findings on uncemented UKAs draw support for the safety profile of this method of fixation, with evidence suggesting it has a potentially lower rate of revision.

This review found the most common indication for revision was osteoarthritis disease progression in other knee compartments, frequently the lateral compartment, and disease progression accounted for a 30.2% prevalence rate of total revisions undertaken. Bearing dislocations was the second most common cause of revision attributing 23.8% of total revision cases. Of note for the remaining complications, 11% experienced a fracture, 6.9% had aseptic component loosening and 7.6% endured persistent pain. Moreover, in this review infection accounted for 5.5% of revisions for uncemented UKAs, which is consistent with the analysis of New Zealand joint registry data by Gupta et al.[40] detailing infections as a 5% proportion of revisions in Oxford uncemented Phase 3 implants. Naturally, complication of an implant with infection

is a particularly challenging concern for surgeon and patient alike due to the nuances of anti-microbial treatments in combination to the operative revision process, yet according to our review and registry data it does appear for uncemented UKAs there are other more prevailing reasons for revision aside to infection.

A pertinent comparison again to the U.K. joint registry data (38) reflects that the uncemented group has a lower risk of revision compared to the cemented group for aseptic loosening (0.42% from 1.00% p<0.001), unexplained pain (0.46% from 0.74%, p =0.03) and lysis (0.04% from 0.15%, p=0.03). Yet it should be noted there was a significant finding of elevated risk in periprosthetic fractures between the uncemented and cemented group (0.26% from 0.09%, p=0.01).

Arthroplasty surgery currently faces aseptic loosening as one of its most common implant failure modes. It is estimated to accounts for a high proportion of indications for revision surgery in primary knee replacements, with revision ratio of 1.22 per 1,000 prosthesis years for cemented TKAs[3]. In this review, aseptic loosening accounted for 10 revision cases (6.9%), whilst literature reports the aseptic loosening proportion of revision is 31% in cemented TKAs, 25% in uncemented TKAs and 36% in cemented UKAs[40]. Uncemented UKAs may appreciably confer a lower risk of aseptic loosening in line with the objective of modern implant designs and their biological surface coatings of creating a highly secure fixation between prosthesis and bone. A recent review demonstrated uncemented components confer a considerably lower risk of revision for aseptic loosening that cemented UKA[41]. Aseptic loosening has been linked to stress shielding caused by inadequate cementation technique, as Liddle et al[17] noted, achieving an adequate cement mantle through a minimally invasive approach presents a technical challenge not seen in cementless fixations. Alternatively, radiolucent lines beneath the tibial component which are described less frequently after cementless fixation compare to cemented UKAs[12,14,15]. Though the clinical significance of these lines is disputed, patients presenting with antero-medial knee pain in combination with radiolucency could be considered to have aseptic loosening of the implant.

Osseointegration of the uncemented prostheses to the native tissue is sought through features of porous coating of the surface either alone or in combination with hydroxyapatite, which have osseoinductive and osseoconductive properties to promote bony ingrowth into the pore space[40]. Improvements in the biological fixation of uncemented UKAs has been developed over time, earlier generations of the unicompartmental knee replacement, such as the PCA UKA had been associated with contentious results, with poor outcomes and high failure rates reported. Initially, the results were promising with Magnussen et al.[42] publishing a 2-year minimum follow-up prospective case series of 51 uncemented PCA implants by a single surgeon in 1990 with satisfactory results in 90% of patients, and initial work by Lindstrand et al.[43] in 1988 with a randomised controlled study between cemented and uncemented PCA UKAs demonstrating in 43 uncemented cases, no cases of revision for infection or loosening within a 1-4 year follow-up period. However, Lindstrand et al.[7] published in 1992 there was significant evidence of polyethylene wear with PCA implants and was not a recommendable prosthesis. Yet, the current modern implants have proceeded to develop to achieve widespread improved outcomes through newer designs, porous and hydroxyapatite coating, greater screw fixation and consequently biological integration [34].

The direct comparison between uncemented and cemented UKAs was performed in 5 studies[8,14,15,19,23], four of the studies[8,14,15,19] comparing OUKAs and Schlueter-Brust et al.[23] comparing Uniglide UKAs. Two studies were randomised controlled trials[14,19], the study by Kendrick et al.[14] focussing on radiostereometric analysis concluded uncemented fixation was similar if not greater than cement fixation, while the randomised controlled trial by Pandit et al.[19] found similar to superior clinical outcomes with shorter operative time in the uncemented group. Campi et al.[8] demonstrated there was no difference at 5-year survivorship between cemented and uncemented UKAs in an independent centre under non-designer surgeons, with 91% cumulative survivorship at 10 years. Positive results for uncemented UKAs were also demonstrated in the non-designer user group study conducted by Kerens et al.[15], and the study by Schlueter-Brust et al.[23] comparing Uniglide UKAs. Overall, the comparative studies between the two fixations demonstrate uncemented UKAs to be a reliable alternative to its cemented counterpart.

There are a few limitations in this review evaluating the current literature on uncemented UKAs. It is evident, there is still a significant lack of large high-powered randomised controlled trials comparing uncemented and cemented UKAs on the objectives of survivorship, clinical outcomes and revision rates. Secondly, in terms of assessment of revision, there was not complete uniformity between the studies for end-point, although most studies used revision for any cause with exchange or addition of a component as end-point,

Epinette et al.[36] used aseptic loosening as a revision end-point and Kerens et al.[15] used revision to total knee arthroplasty. Thirdly, only seven studies attained the highest methodology quality index according to the risk of bias assessment, which further emphasises the greater need for independent unbiased assessment method in well-designed randomised controlled trials. A further evaluation of this study is the findings are largely representative of the Oxford UKA, with minimal representation of other implant designs. Finally due to the heterogeneity across the studies a meta-analysis of the data collected was not felt to be possible, neither an analysis of patient outcomes and revision according to patient demographic parameters.

CONCLUSION

In conclusion, this review finds that uncemented UKAs demonstrate comparable survivorship, clinical outcomes, and safety profile to consider this fixation a suitable alternative to cemented unicompartmental knee replacements in clinical use. The concept does, however, need to be tested in wider populations and across age groups. Use of precision tools for bone preparation and implant placement may have a role to play in greater uptake of uncemented components, although this data is still lacking in literature. The absence of a cementation procedural step, potential reduction in operative time and secure biological osseointegration at a bone-implant interface portray the appealing features of uncemented UKAs.

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