Cementless fixation in medial unicompartmental knee arthroplasty: a systematic review

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Abstract

Purpose. The aim of this study was to evaluate clinical outcome, failures, implant survival and complications encountered with cementless fixation in unicompartmental knee arthroplasty (UKA).

Methods. A systematic review of the literature on cementless fixation in UKA was performed according to the PRISMA guidelines. The following database were comprehensively searched: PubMed, Cochrane, MEDLINE, CINAHL, Embase, and Google Scholar. The keywords “unicompartmental”, “unicondylar”, “partial knee arthroplasty”, and “UKA” were combined with each of the keyword “uncemented”, “cementless” and “survival”, “complications”, “outcome”. The following data were extracted: demographics, clinical outcome, details of failures and revisions, cumulative survival and complications encountered. The risk of bias of each study was estimated with the MINORS score and a further scoring system based on the presence of the primary outcomes.

Results. From a cohort of 63 studies identified using the above methodology, ten papers (1199 knees) were included in the final review. The mean follow-up ranged from 2 to 11 years (median 5 years). The 5-year survival ranged from 90% to 99%, and the 10-year survival from 92 to 97%. There were 48 revisions with an overall revision rate of 0.8 per 100 observed component years. The most common cause of failure was progression of osteoarthritis in the retained compartment (0.9%).

The cumulative incidence of complications and revisions was comparable to that reported in similar studies on cemented UKAs. The advantages of cementless fixation include faster surgical time, avoidance of cementation errors and lower incidence of radiolucent lines.

Conclusions. Cementless fixation is a safe and effective alternative to cementation in medial UKA. Clinical outcome, failures, reoperation rate and survival are similar to those reported for cemented implants with lower incidence of radiolucent lines.

Level of Evidence. Level IV.

Keywords: Unicompartmental Knee Arthroplasty, Cementless, Partial knee Arthroplasty, UKA

Introduction

Unicompartmental knee arthroplasty (UKA) is an effective treatment for anteromedial osteoarthritis of the knee. Likewise for total knee arthroplasty (TKA), cementation is still considered the standard method of fixation for UKA. Cementless fixation in TKA has been widely investigated. Despite early conflicting results, recent evidence showed encouraging outcome and survivor of modern implants [28,19].

In contrast, the experience on cementless fixation in UKA is still limited. Even if cementless options have been available for over 20 years, the poor results of the first cementless UKAs contributed to limit the widespread acceptance of this alternative method of fixation [2,3,11,26,25,24,27]. In the last ten years several specialist centres have reported the results of cementless UKAs with randomised controlled trials and case series, showing excellent clinical outcome and survival and some advantages over cemented implants[13,17,22,23,30,32]. These include faster surgical time and avoidance of cementation errors, which can cause impingement and/or accelerated wear, leading to early failures. In addition, the incidence of radiolucencies around the tibial component is significantly reduced in cementless UKAs [30]. However, some aspects still need to be analysed, including possible complications, causes of failure, clinical outcome, long term survival and the suitability of cementless fixation in specific patient groups.

This systematic review presents the current evidence on cementless medial UKA, with emphasis on (1) clinical outcome, (2) failures and revisions, (3) implant survival and (4) complications encountered.

This is the first systematic review comprehensively reporting the results of modern cementless UKAs.

Materials and Methods

This systematic review has been registered with PROSPERO (http://www.crd.york.ac.uk/PROSPERO) on the 20th of November 2015 (protocol number: CRD42015029477).

Two independent reviewers performed a systematic review of the literature according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The following database were comprehensively searched: PubMed, Cochrane, MEDLINE, CINAHL, Embase, and Google Scholar.

Different combinations of the keywords “unicompartmental”, “unicondylar”, “partial knee arthroplasty” and “UKA” were combined with each of the keywords “uncemented”, “cementless” and “survival”, “complications”, “outcome”. In addition, a hand-search of the bibliography of relevant studies was performed. The last search was performed on the 28th of November 2015. All articles published in English on peer-reviewed journals were considered. Duplicate references were discarded.

To be included, a study needed to meet at least one of the following inclusion criteria: (1) report the outcome with a validated scoring system, (2) report failures and revisions and (3) cumulative survival. Studies with a mean follow-up shorter than two years, studies on experimental implants, literature reviews, case reports, studies on animals, cadavers or in vitro, biomechanical reports, technical notes and letters to editors were excluded. Studies including both cementless and cemented implants or medial and lateral UKAs were included only if the outcome measures, failure rate and/or survival were reported separately and clearly. If two or more studies reported on the same group of patients only the most recent study was included. Studies before 2000 or reporting on old implant designs (as the PCA) were excluded from the present review, since their poor results have been correlated with an obsolete design and / or recognised materials issues, and significantly differ from those of modern UKAs.

There was complete agreement between the reviewers regarding inclusion and exclusion in all cases.

All the abstract of studies meeting the inclusion criteria were independently evaluated, and full-text of relevant papers were retrieved and carefully assessed to confirm eligibility.

Data extraction was then performed independently to reduce the risk of bias. In case of discrepancy, the data extraction was repeated and discussed.

Revision was defined as the exchange or addition of a new component in the knee.

The parameter "revision per 100 observed component years" [29,20] was used to compare the revision rates of individual studies with different follow-up.

The risk of bias of each study has been assessed with the MINORS score[38], a methodological index for evaluation of non-randomised studies, and a further scoring system based on the presence of the primary outcomes of this systematic review (A = clearly reported, B = non reported or unclear) and the number of cases included (A > 100, B = 51-99, C < 50). This modified version of the method previously reported by de Vos-Kerkhof et al.[6] was used to adjust the assessment of the risk of bias to number of patients included in the studies and the clarity in reporting the primary outcome measures of this review. Studies with a MINORS score over 80% were considered at low risk of bias. Studies with a MINORS score lower than 70% were considered at high risk of bias, except for those with three or more "A" in the second scoring system. Results are reported in **table 1.**

Results

Literature search

The literature search resulted in a total of 63 references. After abstract evaluation, 47 papers were discarded because of duplication (12) or off-topic (35). After full-text retrieval and evaluation, 3 further papers were excluded from the study because they failed to meet the inclusion criteria or reported incomplete data. Three further papers[23,30,12] were discarded because the results of the same cohort of patients have been subsequently reported with longer follow-up.

Ten papers were included in the final systematic review. Two of these studies were randomised controlled trials (RCTs) [17,32], two prospective consecutive case series[13,33] and three retrospective case series[1,10,15]. Three further studies were case series, without clear reporting of data collection method [7,21,36]. The PRISMA flowchart is reported in **figure 1**.

Clinical outcome

Seven out of 10 studies [1,10,13,15,32,17,33] reported the clinical outcome using the Oxford Knee Score (OKS). Overall, the mean OKS showed an excellent outcome (score > 41) in four studies, and a good outcome (34 to 41) in three (**Table 2)**. Four studies [1,21,32,33] reported the clinical outcome using the Knee Society Score (KSS), as detailed in **table 3**. All of them reported a good or excellent mean postoperative score according to the KSS criteria [14].

Failures and revisions

All the studies reported the number and details of failures and revisions, summarised in **table 4**.
There were 48 revisions on 1199 cases, with an overall revision rate of 0.8 per 100 observed component years (range 0 - 2.0). The mean follow-up ranged from 2 to 11 years (median 5 years). The number of revisions per 100 observed component years for each study is reported in **table 5**.
The most common cause of failure was progression of osteoarthritis (OA) in retained compartments (n=11 0.9%), followed by bearing dislocation, which occurred in 8 cases (0.7%). Six cases failed for loosening of the tibial component (0.4%). In one of these cases, the authors identified a surgical technique error during implantation, with incomplete seating of the component [13].
Seven failures were caused by wear or polyethylene fracture, all in fixed bearing devices. In total, these complications occurred in 3.2% of cases treated with a fixed bearing device.
The incidence of each cause of failure is reported in **table 6**.
The most common revision surgery was TKA, performed in 25 cases (52%), followed by exchange of polyethylene (wear or dislocation) in 9 cases (19%) and addition of a further unicompartmental implant in 5 cases (10%).

Overall survival

Eight studies reported the overall survival (**table 7)**. Three studies reported the 5-year cumulative survival of the cementless OUKA, ranging from 98.7% and 100%. The Unix and the AMC/Uniglide (Corin, Cirencester, UK) showed a 10-year survival of 92% and 97.4% respectively. Hall et al[10] reported a significant reduction of survival for the Unix at 12 years; however, only a small number of patients were at risk at that stage. The 13-year survival of the Alpina (Biomet, Bridgend, UK) was 88%.

Studies comparing cemented and cementless versions of the same implant

Three studies compared the cementless and cemented version of the OUKA[1,17,32]. Two are randomised controlled trials, and one a retrospective observational study. In the first RCT on 62 patients with 5 years follow-up, Pandit et al.[32] reported no significant difference in any outcome measure between the cemented and cementless groups, except for a superior AKSS functional score and a significantly lower incidence of radiolucencies in the cementless group. Furthermore, surgical time was significantly shorter in the cementless group.

In the second RCT, Kendrick et al.[17] compared the migration of components of cemented and cementless OUKA with Radiostereometric analysis (RSA) at 2 years of follow-up. The authors concluded that the cementless fixation is “at least as good, if not better than, that of cemented OUKA”. The study confirmed a significantly lower incidence of RLs in the cementless components. There was no significant difference in the OKS between the two groups.

The third study comparing the cemented and cementless versions of the OUKA is a retrospective observational study on 263 cases, 141 of which were cemented and 122 cementless. The mean follow-up was 42 months in the cemented group and 30 months in the cementless group. The clinical results and survival showed no significant difference between the two groups. The surgical time was shorter in the cementless group [1].

Discussion

The most relevant finding of this review is that cementless fixation is effective and safe in all patients in whom it was used. Cementless fixation has many advantages, including shorter surgical time, avoidance of cementation errors, lower incidence of radiolucent lines and reliable fixation. None of the studies suggested any specific contraindications to use of cementless fixation. However, the follow-up is still short term for most studies.

Cementation is an adequate fixation method for UKA, and is considered the standard technique. However, aseptic loosening, misinterpretation of radiolucent lines (RLs) and cementation errors are among the most common causes of failure of cemented implants. The detection of "physiological" RLs is a common finding in cemented implant radiographies. Radiolucent lines have been correlated with the presence of some fibrocartilaginous tissue at the bone-prosthesis interface [16]. Even if physiological radiolucent lines are detected in well functioning implants and do not affect the clinical outcome or survival [9], they may be the manifestation of a sub-optimal fixation. Furthermore, RLs are a frequent cause of misdiagnosis of loosening, especially in low volume centres or less experienced hands, with a consequent increase in the cumulative revision rate as evident from National Joint Registries[23].

Cementless fixation can avoid technical errors related to cementation, like inadequate cementation, presence of loose fragments or excess cement causing impingement. The lower incidence of RLs could limit the number of misdiagnosis of loosening and therefore “unnecessary” revisions.

UKAs are more suitable for cementless fixation than TKAs, as the mechanical environment at the bone-implant interface is very different. In UKAs the loads under the tibial component are mainly compressive, both when the loads across the knee are central or eccentric. Furthermore, UKAs have no tibio-femoral constrains, that are responsible for significant shear stress and tilting. Especially in mobile bearing UKAs, shear forces are minimal[8]. Likewise for TKA, cementless options for UKA include porous coating, hydroxyapatite coating, screw fixation and modified implant design.

In 1988, Lindstrand first published results of randomised trial comparing cemented and cementless PCA (Porous Coated Anatomic) unicompartmental implant in 93 knees with follow-up ranging from 1 to 4 years,

reporting satisfactory results and no cases of loosening in neither group[25]. In 1990, Magnussen et al. published a case series reporting the results of 51 PCA cementless unicompartmental knees, with satisfactory results in 90% of patients and no failures due to component loosening at a final follow-up ranging from 24 to 40 months[27]. However, in an follow-up extension (4 to 8 years) of the PCA study group, Linstrand[24] reported 9 failures (7 cemented, 2 uncemented) with 6 revisions for loosening of the femoral component (2), tibial component (2), or both components (l), and polyethylene wear (1). All revised tibial components showed polyethylene wear and the weight-bearing radiographs revealed major polyethylene wear in an additional 14 knees, revealing a relevant problem of the PCA implant, confirmed by further studies[4]. Swank et al. reported in 1993 the results of a small series containing both cemented and cementless UKAs showing slightly better results for the cementless implants, although the overall results were poor with 12% failure at 4 years with an high rate of polyethylene wear[40]. These studies on early cementless UKAs were excluded from the present review, since the controversial and often poor results have been clearly ascribed to materials and design issues.
The studies included in this review report the results of modern cementless designs. All the studies reported good or excellent results for cementless UKAs. Three studies compared the clinical outcome of cementless and cemented UKAs. The outcome measures resulted comparable for the two groups in all the studies, except for a superior functional KSS reported by Pandit et al[32]. However, most of these studies are probably underpowered to identify a relevant difference in the clinical outcome. Further randomised controlled trials or case-control studies are needed to draw definitive conclusions.
The cumulative incidence of complications and revisions is comparable to that reported in similar studies on cemented UKAs [31,18]. In a review analysing the causes of failure of the Oxford UKA Kim et al.[18] reported an overall failure rate of 4.5% with a median follow-up of 5.6 years (range 0.1–11). Considering only the studies on the cementless OUKA, the overall failure rate was 2.1% with a median follow-up of 3.4 years (range 1-10.2). The lower incidence of failure could be partially justified by the shorter follow-up of the cementless OUKA. A longer follow-up is needed to compare the results and draw definitive conclusion.
Loosening of one of the components occurred in six cases (0.5%), one of which was considered a surgical error by the authors. This confirms that cementless fixation is a reliable method in UKA. All cases of loosening regarded the tibial component. The randomised controlled trial by Kendrick et al.[17] showed no difference in second year migration between the cemented and cementless versions of the OUKA. Second year migration has been shown to be predictive of subsequent loosening. This, in association with the lower incidence of peri-prosthetic radiolucencies, allowed the authors to conclude that cementless fixation in OUKA is at least as good as cementation.
There is an unfounded perception that cementless fixation is not suitable for all patients, for example old age or patients with osteoporosis. Some of the authors may tend to offer cementless fixation to different cohort of patients, such as younger population. However, none of the studies mentioned different indications for cementless fixation, considered parameters such old age or poor bone quality as exclusion criteria or performed a formal preoperative assessment of bone quality (e.g. using DEXA scan). Nevertheless, the incidence of

complications related to bone quality and or fixation was not more frequent than that reported for cemented implants.

Medial tibial condyle fracture is an uncommon but well-recognised complication of cemented and cementless UKAs [34,41]. However, some surgeons are concerned about a higher incidence of fractures in cementless implants. The total incidence of tibial plateau fractures in this study was 0.4%. Kim reported an overall incidence of 0.2% in cemented OUKA. Most of the fractures occurred intra-operatively or in the early post-operative weeks; therefore, the different length of follow-up should not significantly influence the comparison between this two studies. Even if the available data do not permit a formal statistical comparison, the incidence of fractures in cementless UKAs seems higher than previously reported for cemented implants. The cause is likely to be multifactorial, combining the risk factors previously described for the cemented UKAs[5,37] with a higher push in force generated by the interference. Furthermore, the introduction of most of the cementless devices is recent and the majority of the case series inevitably include surgeries performed at the beginning of surgeons' learning curve. This limit has been discussed by some of the authors, and must be taken into account as it may have increased the incidence of such complications. However, considering only cementless OUKA the overall incidence of fractures was 0.1%, which is similar to the rate reported by Kim for the cemented version of the implant. The risk of fracture can be reduced by strict adherence to surgical technique, adequate clearing of peg and keel slots, avoidance of damage to the posterior cortical bone and delicate impaction using a small hammer.

The 5-year (98.7 to 100%) and 10-year (92 to 97.4%) survival rates reported in these studies are excellent.

The study by Jeer et al. reported a 90% survival of the LCS UKA system with 6 years of follow-up. However, four out of the six failures reported in this study were considered as technical errors, and all occurred at the beginning of the learning curve with the new implant. The survival rates reported for cementless implants are comparable to those published for similar cohorts of cemented UKAs [31,39].

The overall rate of revisions per 100 observed component years was 0.8, ranging from 0 to 2.0. This is based on the assumption that the revision rate is constant, and does not take into account that there may be a high early revision rate. Consequently, this tends to over-estimate the revision rate in short term follow-up studies. However, it is helpful when comparing studies with different lengths of follow-up [29].

The number of cementless UKAs reported in National Joint Registries is still small, and usually reported cumulatively with cemented UKAs. However, the last report of the New Zealand Joint Registry contains a significant number of cementless UKAs, with separate reporting of revision rate. The revision rate for cementless UKA was 0.67 /100 components-year (95% CI: 0.49 – 0.90), while the revision rate for cemented UKA was 1.33 /100 components-year (95% CI: 1.23 – 1.44). According to these data, the revision rate of cementless implants appears significantly lower.

The vast majority of cementless implants in the New Zealand Registry are OUKAs. Similarly, in the studies included in this review the cementless OUKA was used in most cases (833/1199, 70%). Therefore, the results of this specific design had a strong influence on the overall conclusions; in contrast, the evidence supporting the use of other cementless devices is weaker. The design of cementless implants appears to be critical in achieving stability and reliable fixation. Consequently, detailed studies are necessary prior to the introduction of new cementless devices into clinical practice, and after the introduction careful follow-up is required.

This study has some limitations. First, except for the two randomised controlled trials, most of the included studies are case series with a low level of evidence (level IV). Two of the studies that have been included have a poor MINORS score and have been considered at high risk of bias. The clinical outcome has been reported in a reasonably homogeneous manner, mainly with the OKS and KSS scores. However, there is a significant variation in the follow-up length and the incompleteness of some of the data does not permit a formal statistical analysis of the results. The difference between implant designs represents a further source of variability. In addition, there is a possible risk of publication bias, with the tendency to publish good results and neglect poor results. The data from National Joint Registries can only partially compensate this problem, since they involve further limitations such us underreporting of re-operations, revisions and intraoperative complications [35].

Conclusions

Cementless fixation is a safe and effective alternative to cementation in medial unicompartmental knee arthroplasty. Clinical outcome, failures, reoperation rate and survival are similar to those reported for cemented implants. The advantages of cementless fixation include lower incidence of radiolucent lines, avoidance of cementation errors and faster surgical time.

The results of this study suggest that cementless UKAs can be safely used in the clinical practice.

List of abbreviations

AMOA: Anteromedial Osteoarthritis
CI: Confidence intervals
KSS: Knee Society Score
N.R.: Not reported
OA: Osteoarthritis
OKS: Oxford Knee Score
OUKA: Oxford Unicompartmental Knee Arthroplasty
RCT: Randomised Controlled Trial
RLs: Radiolucent lines
RSA: Radiostereometric Analysis
SD: Standard Deviation
TKA: Total Knee Arthroplasty
UKA: Unicompartmental Knee Arthroplasty

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Conflict of interest

Some of the authors have received or will receive benefits for personal or professional use from a commercial party related directly or indirectly to the subject of this article. In addition, benefits have been or will be directed to a research fund, foundation, educational institution, or other non-profit organisation with which one or more of the authors are associated.

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Tables

Table 1. Risk of bias of the studies included in the review

Study	MINORS	Score 2				Bias Risk
		Clinical outcome	Failures	Survival	Number of cases	
Akan et al. 2013	16/24	A	A	B	A	Low
Forsythe et al. 2000	7/16	A	A	B	B	High
Hall et al. 2013	11/16	A	A	A	B	Low
Hooper et al. 2015	12/16	A	A	A	A	Low
Jeer et al. 2004	11/16	A	A	A	B	Low
Kendrick et al. 2015	23/24	A	B	B	C	Low
Lecuire et al. 2014	11/16	A	A	A	B	Low
Pandit et al. 2013	24/24	A	A	B	C	Low
Pandit et al. 2015	13/16	A	A	A	A	Low
Schlueter-Brust et al. 2014	9/16	B	A	A	B	High

Table 2. Studies reporting postoperative Oxford Knee Score

Study	Study design	Implant	Cases *(n)*	Follow-up *(y)*	Age *(y)*	M/F *(patients)*	Pre-op. OKS *(SD, range)*	Post-op. OKS *(SD, range)*
Akan et al. 2013	n.r., consecutive	Cementless OUKA	122	2.5 (range 2-3)	64.9 (35-79)	11/104	20.9 (6.2, n.r.)	41.1 (6.0, n.r.)
Hall et al. 2013	Retrospective	Unix	85	10 (range 8-13)	60-90	37/28	n.r.	38 (n.r., 12-48)
Hooper et al. 2015	Prospective, consecutive	Cementless OUKA	147	5	63.6 (39-86)	81/45	22.9 (8.4, 2 - 44)	42.4 (6.5, 18 - 48)
Jeer et al. 2004	n.r., consecutive	LCS UKA system	66	5.9 (range 5.1–6.6)	69 (54.4–87.4)	26/26	20.5 (n.r., 13–32)	37.0 (n.r., 17– 48)
Kendrick et al. 2015	Randomised controlled trial	Cementless OUKA	22	2	67.6 (49.1 - 81.6)	13/9	23.68 (n.r., 12 - 36)	41.52 (n.r., 24 - 48)
Pandit et al. 2013	Randomised controlled trial	Cementless OUKA	30	5	63.8 (45-82)	16/14	21.1 (6.1, n.r.)	39.4 (9.9, n.r.)
Pandit et al. 2015	Prospective, consecutive	Cementless OUKA	512	3.4 (1.0-10.2)	65.1 (35 - 94)	299/221	27 (9, n.r.)	43 (7, n.r.)

n.r. = not reported

Table 3. Studies reporting preoperative and postoperative KSS

Study	Study design	Implant	Cases *(n)*	Follow-up *(y)*	Age	M/F *(patients)*	Pre-op. KSS *(SD, range)*	Post-op. KSS *(SD, range)*
Akan et al. 2013	Retrospective, consecutive	Cementless OUKA	122	2.5 (2-3)	64.9 (35-79)	11/104	Obj. 43.8 (9.2, n.r.) Fun. 59.0 (11.6, n.r.) Total: 102.8 (14.8, n.r.)	Obj. 87.6 (10.2, n.r.) Fun. 90.2 (6.5, n.r.) Total: 177.8 (12.1, n.r.)
Lecuire et al. 2014	n.r., consecutive	Alpina	65	11 (10-13)	71.8 (50-80)	18/47	Obj.: n.r. Func.: n.r. Total: 119.3 (16.8, n.r.)	Obj.: n.r. Func.: n.r. Total: 171.4 (25.3, n.r.)
Pandit et al. 2013	Randomised controlled trial	Cementless OUKA	30	5 (5)	63.8 (45-82)	16/14	Obj.: 41.6 (11.1, n.r.) Func.: 60.3 (13.8, n.r.) Total: 101.9 (17.7, n.r.)	Obj.: 78.8 (14.0, n.r.) Func.: 92.0 (12.7, n.r.) Total: 170.8 (18.9, n.r.)
Pandit et al. 2015	Prospective, consecutive	Cementless OUKA	512	3.4 (1.0-10.2)	65.1 (35 - 94)	299/221	Obj.: 52 (20, n.r.) Func.: 71 (17 n.r.) Total: 123 (n.r.)	Obj.: 81 (13, n.r.) Func.: 86 (16, n.r.) Total: 167 (n.r.)

Table 4. Causes of failure and revision surgeries

Study	Implant	Mobile /fixed bearing	Cases *(n)*	Mean FUP *(range)*	Revisions	Causes of failure, reoperation *(time after primary UKA)*
Akan et al. 2013	Cementless OUKA	MB	122	2.5 (2-3)	6	2 Unexplained pain, 2 TKA (n.r.); 3 Bearing dislocation, 1 bearing exchange, 2 TKA (n.r.); 1 Tibial plateau fracture, TKA (n.r.)
Forsythe et al. 2000	Whiteside Ortholoc	FB	72	3.4 (1-8)	5	1 Persistent pain, TKA (7.5); 3 Tibial condyle fracture, 3 ORIF (intra-op.); 1 Femoral condyle fracture, ORIF (intra-op.);
Hall et al. 2013	Unix	FB	85	10 (8-13)	7	4 Aseptic loosening (tibial comp.), 4 TKA (n.r.); 1 Infection, TKA (n.r.); 2 OA progression, 2 TKA (n.r.);
Hooper et al. 2015	Cementless OUKA	MB	147	5	6	1 Early loosening of tibia, TKA (12m); 1 Lateral and PFJ OA progression, TKA (8y); 2 Bearing dislocations, 1 bearing exchance (16m), 1 ACLR + bearing exchange (n.r.); 2 Late onset of RA, 2 lateral UKAs (4y);
Jeer et al. 2004	LCS UKA system	MB	66	5.9 (5.1–6.6)	5	2 Lateral OA progression (overcorrection), 2 TKA (5.3, 5.4); 1 Tibial plateau fracture, TKA (2w); 2 Unexplained pain, 2 TKA (11m, 23m);
Kendrick et al. 2015	Cementless OUKA	MB	22	2	0	

Lecuire et al. 2014	Alpina	FB	65	11 (10-13)	11	2 Lateral OA progression, 2 TKA (1y. 7y); 1 Unexplained pain, TKA (8y); 1 ACL tear, TKA (9y); 3 PE fractures, 3 revision UKA (4y, 5y, 5y); 4 PE wear, 4 PE exchange (2-6y);
Pandit et al. 2013	Cementless OUKA	MB	30	5	0	
Pandit et al. 2015	Cementless OUKA	MB	512	3.4 (1.0-10.2)	6	4 OA progression, 2 lateral UKA (4y, 4.2y), 1 PFJR (2.1y), 1 TKA (6.9y); 2 Bearing dislocation, 2 bearing exchange (1.8y, 2.3y)
Schlueter-Brust et al. 2014	AMC/Uniglide	MB	78	10	2	1 Aseptic loosening (tibia), tibial component revised (2.8y); 1 Bearing dislocation, bearing exchange (6.5y);
	Total		**1199**		**48**	

Table 5. Revisions per 100 observed component years

Study	Implant	Cases *(n)*	Revisions	Mean FUP	Observed components years	Revisions per 100 observed component years
Akan et al. 2013	Cementless OUKA	122	6	2.5	305	2.0
Forsythe et al. 2000	Whiteside Ortholoc	72	5	3.4	245	2.0
Hall et al. 2013	Unix	85	7	10	850	0.8
Hooper et al. 2015	Cementless OUKA	147	6	5	735	0.8
Jeer et al. 2004	LCS UKA system	66	5	5.9	389	1.3
Kendrick et al. 2015	Cementless OUKA	22	0	2	44	0
Lecuire et al. 2014	Alpina	65	11	11	715	1.5
Pandit et al. 2013	Cementless OUKA	30	0	5	150	0
Pandit et al. 2015	Cementless OUKA	512	6	3.4	1741	0.3
Schlueter-Brust et al. 2014	AMC/Uniglide	78	2	10	780	0.3
Total		**1199**	**48**		**5954**	**0.8**

Table 6. Causes of failure, incidence and incidence rate.

Cause	Incidence	Incidence rate *(in percentage)*	Comments
OA progression	11	0.9	
Bearing dislocations	8	0.7	All mobile bearings
Other	7	0.6	
Unexplained pain	6	0.5	
Loosening	6	0.5	All tibial components
Tibial plateau fracture	5	0.4	
Wear	4	0.3	All fixed bearings
Infection	1	0.1	

Table 7. Overall survival.

Study	Implant	Cases	Mean follow-up *(years)*	Overall survival
Hall et al. 2013	Unix	85	10	92% at 10 years (34 at risk); 76% at 12 years (11 at risk)
Hooper et al. 2015	Cementless OUKA	147	5	98.7% at 5 years (136 at risk)
Jeer et al. 2004	LCS UKA system	66	5.9	89.7% at 5 years (n.r.)
Kendrick et al. 2015	Cementless OUKA	22	2	100% at 2 years (22 at risk)
Lecuire et al. 2014	Alpina	65	11	88% at 13 years (n.r)
Pandit et al. 2013	Cementless OUKA	30	5	100% at 5 years (28 at risk)
Pandit et al. 2015	Cementless OUKA	512	3.4	98.7% at 5 years (57 at risk)
Schlueter-Brust et al. 2014	AMC/Uniglide	78	10	97.4% at 10 years (n.r.)

Figures

Figure 1: PRISMA flow diagram