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Short-term survival of cementless Oxford unicondylar knee arthroplasty based on the Finnish Arthroplasty Register

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ABSTRACT

Background: Cementless unicondylar knee arthroplasty (UKA) was introduced to secure long-term fixation and reduce the risk of revision. Experience with cementless UKA fixation is limited.
Methods: The short-term survival (up to five years) of cementless Oxford UKA was assessed using data from the Finish Arthroplasty Register and was compared with that of cemented Oxford 3 UKA and total knee arthroplasty (TKA). Datawere obtained, from the Finnish Arthroplasty Register, on 1076 cementless Oxford UKAs and 2279 cemented Oxford 3 UKAs performed for primary osteoarthritis in 2005-2015. The Kaplan-Meier method, with revision for any reason as the endpoint, was used to assess the survival of these two UKA groups, and the results were compared with that of 65,563 cemented TKAs treated for primary osteoarthritis over the same period. The risk of revision of both Oxford prostheses was compared using Cox regression model, with adjustment for age and sex, with the cemented TKA group as reference.
Results: The three-year survival was 93.7% for the cementless Oxford, 92.2% for the cemented Oxford 3, and 97.3% for the cemented TKA. The corresponding figures at five years were 92.3%, 88.9%, and 96.6%, respectively. The revision rate for both the cementless Oxford and the cemented Oxford 3 was significantly increased when compared with the cemented TKA ($P < 0.001$).
Conclusions: The survival of the cementless Oxford method was higher than that of the cemented Oxford 3 in the short term. The overall survival of Oxford UKA was poor in comparison with contemporary TKAs.

1. Introduction

Total knee arthroplasty (TKA) is the gold standard for treatment of symptomatic osteoarthritis (OA) of the knee when conservative treatment is insufficient. In addition to TKA, unicompartmental knee arthroplasty (UKA) can be used to treat OA when it is confined to a single compartment. Medial UKA may have some advantages over TKA (e.g. faster recovery, reduced perioperative morbidity and mortality, subjective preference for a more normal-feeling knee, lower cost, and more rapid return to work and sport) [1,2].

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The standard method of fixation for UKA is cementation. Cemented UKAs are commonly performed using a minimally invasive technique; however, this is a challenging procedure since cementation errors may lead to loosening, pain, and excess wear [3]. Cementation of unicompartmental prostheses may be especially problematic compared with TKA because the medial tibial bone is often very sclerotic and suboptimal for cementing. In TKA, cemented fixation adheres not only to medial but also to the cancellous lateral tibial bone tissue, which enhances fixation.

Analyses of data in arthroplasty registers from Finland, Sweden, Australia, New Zealand, and the United Kingdom have repeatedly reported inferior survival of cemented UKAs compared with cemented TKAs [4–9]. Consequently, cementless UKA was introduced to secure long-term fixation and reduce the risk of revision. So far, the experience with cementless fixation in UKAs has been rather limited. Nevertheless, several reports over the recent five to 10 years have claimed that cementless UKAs may be associated with good clinical and radiological outcomes, and that cementless implants may have some advantages over cemented implants [3,10–13].

The Oxford implant is the most common cemented UKA design. It has a congruent mobile bearing to minimise wear (Zimmer Biomet, UK) [4,7]. A cementless version of the Oxford has been introduced; it has a porous titanium and calcium hydroxyapatite coating. According to data from the New Zealand registry, implant survival of the cementless Oxford version is higher than that of the cemented Oxford 3 version [8].

The cementless Oxford version is currently the market leader in Finland [5]. The aim of this study was to assess the short-term survival of the cementless Oxford UKA device on the basis of data from the Finnish Arthroplasty Register (FAR), and to compare its survival with those of the cemented Oxford 3 UKA and cemented TKA reference group. Short-term was defined as a time span of up to five years.

2. Patients and methods

The FAR has collected information on total joint replacements since 1980 [14]. Orthopaedic units are obliged to provide all information that is essential for the maintenance of the register to the Finnish National Institute for Health and Welfare. Dates of death are obtained from the Population Information System maintained by the Population Register Centre. Data capture of the FAR is high when compared with that of the Hospital Discharge Register [5]. The FAR data for 2005–2017 are currently based on implant catalogue numbers, and therefore cementless and cemented Oxford devices are able to be separately assessed.

For this study, data from 1076 cementless Oxford UKAs, 2279 cemented Oxford 3 UKAs, and 65,563 cemented TKAs indicated for the treatment of primary OA in Finland during 2005–2015 were included. All data were gathered from the FAR database. The TKA reference group consisted of the three most common brands used in Finland: Triathlon Cruciate Retaining (CR) (Stryker, Mahwah, NJ), Nexgen flex CR (Zimmer Biomet, Warsaw, IN), and PFC Sigma CR (DePuy, Warsaw, IN). There were 252 bilateral Oxford 3, 130 bilateral cementless Oxford, and 11,287 bilateral TKA implants.

2.1. Statistics

Crude implant survival of the cementless Oxford, cemented Oxford 3, and cemented TKA control group was assessed using Kaplan–Meier analysis. The Cox regression model was used to assess the differences in the revision rates of the devices and to adjust for any confounding factors. In the Cox model, the reference group was the cemented TKA. Both UKA groups were compared with the reference group. Revisions were linked to the primary operation through the personal identification numbers. The survival endpoint was defined as the revision, when either any of the components or the entire implant was removed or exchanged. The first revision for any reason served as an endpoint. Kaplan–Meier survival data were used to construct the crude survival probabilities of the implants, with 95% confidence interval (95% CI). Patients who died during the follow-up period (until December 31 2015) were not included. Factors studied with the Cox model were age groups <55 years and ≥ 55 years, and sex.

The proportional hazards assumption of the Cox models was checked by inspecting the Kaplan–Meier graphs. The survival rates of the Oxford implants intersected at approximately 18 months of follow-up. For the Cox analyses comparing the cementless Oxford, the cemented Oxford 3, and the cemented TKA reference group, the total follow-up time was divided into the following two periods: 0–18 months and >18 months, because the proportional hazards assumption was not fulfilled for the total follow-up. For the shorter follow-up, the knees with a follow-up >18 months and for the longer time period, the knees with a follow-up of <18 months were excluded from the analyses.

The inclusion of bilateral cases in a survival analysis violates the basic assumption that all cases are independent. However, several reports have shown that the effect of including bilateral cases in studies of hip and knee joint prosthesis survival, as performed in the current study, is negligible [15,16]. The Wald test was used to test the estimated hazard ratios. The between-group differences were considered to be statistically significant if the P-values were <0.05 in a two-tailed test.

3. Results

Demographic data are shown in Table 1. The main reason for revision was 'other reason/missing data' for all study groups: 31% for cementless Oxford, 58% for cemented Oxford 3, and 42% for the cemented TKA reference group (Table 2). The main reason for the revision of the diagnoses that were available was 'insert dislocation' for the cementless Oxford method (16%), 'aseptic loosening of the tibial component' for the cemented Oxford 3 procedure (10%), and 'infection' for the cemented TKA reference group (21%).

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Table 1
Demographic data for cementless Oxford, cemented Oxford 3, and cemented total knee arthroplasty.

Demographic	Cementless Oxford	Cemented Oxford 3	Cemented TKA
N	1076	2279	65,563
Bilateral, n	130	252	11,287
Follow-up, years			
Mean	2.7	7.4	4.9
Minimum	0.05	0.05	0.003
Maximum	7.8	11.7	11.7
Median	2.1	7.9	4.5
Males, %	44.1	39.1	34.7
Age, mean (SD)	61.5 (9.3)	62.1 (9.6)	68.4 (9.3)
Implanting period	2008–2015	2005–2014	2005–2015
Year 2005, n	0	334	1920
Year 2006, n	0	413	3081
Year 2007, n	0	382	4972
Year 2008, n	1	338	5434
Year 2009, n	15	275	5792
Year 2010, n	79	233	6322
Year 2011, n	90	188	6430
Year 2012, n	113	106	7550
Year 2013, n	142	9	7916
Year 2014, n	257	1	7919
Year 2015, n	379	0	8227
Number of hospitals	20	46	64

TKA, total knee arthroplasty; SD, standard deviation; n, number.

The three-year survival was 93.7% (95% CI 92.1–95.4) for the cementless Oxford method, 92.2% (95% CI 91.1–93.3) for cemented Oxford 3, and 97.3% (95% CI 97.1–97.4) for the cemented TKA reference group (Table 3, Figure 1). The three-year survival of the cementless UKA and cemented UKA was the same (confidence limits were overlapping). The five-year survival of the cementless UKA was significantly higher compared to that of the cemented UKA (no overlap of the confidence limits). The corresponding figures at five years were 92.3% (95% CI 90.3–94.4), 88.9% (95% CI 87.6–90.2), and 96.6% (95% CI 96.4–96.7) (Table 3, Figure 1).

The adjusted overall revision rate of the cemented Oxford 3 was 3.0 (95% CI 2.7–3.4, $P < 0.001$) and of cementless Oxford 2.1 (95% CI 1.6–2.7, $P < 0.001$) compared with that of the cemented TKA reference group. During the first 18 months, the adjusted revision rate of the cemented Oxford 3 was 3.7 (95% CI 3.4–4.2, $P < 0.001$) and of the cementless Oxford 1.7 (95% CI 1.3–2.2, $P < 0.001$) compared with the reference group. In the >18-month follow-up group, the adjusted revision rate of the cemented Oxford 3 was 3.7 (95% CI 3.2–4.2, $P < 0.001$) and of the cementless Oxford 1.9 (95% CI 1.2–3.0, $P = 0.006$) compared with the reference group (Table 4).

4. Discussion

It was found that the short-term survival of the cementless Oxford method was higher than that of the cemented Oxford 3 method. Also, the overall survival of both UKA types was inferior to that of cemented TKAs.

It is acknowledged that this study had some limitations. First, as is common in register-based studies, implant survival was the only outcome that was able to be assessed. Patient-reported outcome measures were not included in the available data on FAR

Table 2
Reasons for revision.

Reason for revision	Cementless Oxford n (%)	Cemented Oxford 3 n (%)	Cemented TKA reference group n (%)
Insert dislocation	10 (16%)	10 (3%)	19 (1%)
Aseptic loosening of tibial component	8 (13%)	35 (10%)	50 (2%)
Malposition	7 (11%)	15 (4%)	145 (7%)
Fracture	6 (9%)	2 (1%)	46 (2%)
Pain only	6 (9%)	23 (7%)	150 (7%)
Infection	3 (5%)	12 (4%)	434 (12%)
Instability	3 (5%)	14 (4%)	171 (8%)
Aseptic loosening of femoral component	1 (2%)	27 (8%)	64 (3%)
Implant breakage	0 (0%)	1 (0%)	1 (0%)
Patellofemoral arthrosis progressing	0 (0%)	6 (2%)	113 (5%)
Stiffness	0 (0%)	0 (0%)	12 (1%)
Other reason or missing data	20 (31%)	197 (58%)	889 (42%)
All	64 (100%)	342 (100%)	2094 (100%)

TKA, total knee arthroplasty.

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Table 3
Kaplan–Meier survival of cementless Oxford, cemented Oxford 3, and cemented total knee arthroplasty reference at three and five years. Kaplan–Meier survival of cemented Oxford 3 and cemented total knee arthroplasty reference group at 10 years are also presented.

Implant type	3 year		5 year		10 year	
	At risk	Survival % (95% CI)	At risk	Survival % (95% CI)	At risk	Survival % (95% CI)
Cementless Oxford	365	93.7 (92.1–95.4)	149	92.3 (90.3–94.4)	–	–
Cemented Oxford 3	2077	92.2 (91.1–93.3)	1826	88.9 (87.6–90.2)	466	82.6 (80.8–84.5)
Cemented TKA reference group	44,560	97.3 (97.1–97.4)	28,801	96.6 (96.4–96.7)	3308	95.3 (95.1–95.6)

CI, confidence interval; TKA, total knee arthroplasty.

contents. Unicondylar knee arthroplasty patients may well have a faster recovery time, reduced perioperative morbidity, and a subjective preference for a more normal-feeling knee than TKA patients, but these matters were not addressed in the current study.

Second, data regarding the patients' medical histories, comorbidities, and knee radiographs were not available. Comparing UKA results with TKA results is complicated. Even if patients were matched for age and sex, the characteristics of patients undergoing UKA and TKA may be quite different. In general, patients undergoing UKA may be more active and have higher expectations after surgery.

Third, surgeon level data were not available in the FAR. Surgical volume is an important predictor of success after UKA. Surgeons performing ≤12 UKAs per year (i.e. most surgeons) have a double rate of revision compared with surgeons performing >12 UKAs per year [17]. The relationship between the popularity of UKA and revision rate is complex and non-linear. Statistically, the results are optimal when between 40 and 60% of all arthroplasties are UKAs. Surgeons who perform the fewest UKAs (up to five percent of all arthroplasties) have the highest revision rates [18]. The UKA procedures included in the current study may have been performed by low-volume surgeons, which would explain the overall high revision rate of UKA in this study.

Before revision of the FAR register, which was completed in May 2014, the accuracy of reporting the indications for revision in FAR was poor. The National Institute for Health and Welfare has been responsible for managing FAR since December 2009, and guidance from the Orthopedic Society may have been insufficient. Older data were not appropriate for a precise assessment of the indications for arthroplasty revisions. Furthermore, check-ups for missing data were not systematically performed, and hospitals were not informed if there were any data shortages. For these historical reasons, 31% of the indications for revisions of the cementless Oxford UKA were coded for the current study either as other reasons or missing data. The proportion of other reason/missing data was even higher for the cemented Oxford 3 UKA and the cemented TKA reference group. Thus, assessment of the indications for revisions was incomplete for reasons related to insufficient registry data. Overall, data on primary and revision TKA in FAR is very comprehensive and thus almost all primary TKAs and most revision TKAs have been reported to FAR, as shown by comparison with the data in the National Discharge Register. Data on primary TKAs covered 95% and on revisions 85% of all procedures performed in Finnish hospitals during this study period (2005–2015) [5].

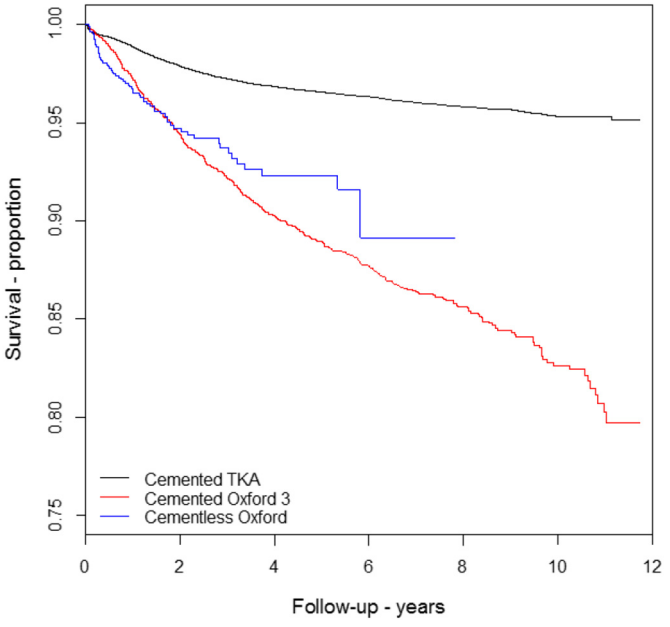

Figure 1. Kaplan–Meier survival of cementless Oxford, cemented Oxford 3, and cemented total knee arthroplasty reference group.

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Table 4
Adjusted revision risk (age, sex) for revision of any reason for cementless Oxford and cemented Oxford 3, cemented total knee arthroplasty as the reference group.

Implant type	Follow-up Overall		Follow-up 0–18 months		Follow-up >18 months	
	RR (95% CI)	*P*	RR (95% CI)	*P*	RR (95% CI)	*P*
Cemented TKA	1	–	1	–	1	–
Cemented Oxford 3	3.0 (2.7–3.4)	<0.001	3.7 (3.4–4.2)	<0.001	3.7 (3.2–4.2)	<0.001
Cementless Oxford	2.1 (1.6–2.7)	<0.001	1.7 (1.3–2.2)	<0.001	1.9 (1.2–3.0)	<0.006

RR, revision risk; TKA, total knee arthroplasty; CI, confidence interval.

The strengths of this study were its population-based design, prospective collection of data, and large and comprehensive sample size. The complete follow-up of the study population limited the possibility of selection bias risk that is associated with register studies.

According to the New Zealand Registry with data from 2000 to 2017, the revision rate of 3862 cementless Oxfords per 100 component years was 0.76 (0.63–0.91), whereas that of 4080 cemented Oxford 3 procedures was 1.38 (1.26–1.50) [8]. The current findings support these findings, although component years was not used in reporting. It seems that the short-term implant survival of the cementless Oxford method has really improved when compared to that of the cemented Oxford 3 procedure. However, at least in Finland, the use of the cemented Oxford 3 has ended, and in 2015 all UKAs were cementless Oxfords (Table 1). Thus, the era when cemented and cementless Oxfords were implanted is not the same. Overall, the indications for UKA surgery have become more stringent. It has been well established that symptomatic patients who have radiologically mild OA have an increased risk of revision [19,20]. When indications became more stringent, the need of 'unnecessary' revisions (for pain alone) may decrease. Finland has been systematically educating surgeons to consider the fact that preoperative radiological OA grade must be bone-to-bone in UKA surgery. These circumstances have probably increased the survival of the cementless Oxford device in comparison with the cemented one in Finland.

According to Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) data, the 10-year cumulative revision frequency of the cemented Oxford 3 implant is 14.8% and of the cementless Oxford implant 13.6% [4]. The equivalent 10-year Kaplan–Meier estimate of the cumulative percentage probability of first revision in England and Wales for the Oxford 3 implant is 11.4% [7], and in Sweden 13% [9]. Current data corroborate these findings, although the revision rate of the cemented Oxford 3 implant is slightly higher in Finland than in other countries.

Implant survival of fixed bearing UKAs may be increased when compared with that of mobile bearing UKAs like the Oxford, since bearing dislocations are not possible with the former implant. The 10-year Kaplan–Meier estimate of the cumulative frequency of revision in England and Wales of fixed bearing UKAs is 9.9% compared with 11.8% of mobile bearing UKAs [7]. According to AOANJRR data, the 10-year cumulative percent revision of ZUK (Zimmer Biomet, UK) fixed bearing UKA was 8.6% of 6785 UKAs [4]. According to the New Zealand Registry, the revision rate of 1328 ZUK fixed bearing UKAs per 100 component years is 0.52 (0.33–0.76) [8]. These data are encouraging for fixed bearing UKAs and especially for ZUK, which is the current market leader of fixed bearing UKAs in the named countries. Since fixed bearing UKA data are not available in the FAR, the current situation in Finland is unknown.

Based on the New Zealand Joint Registry (NZJR), the most common reasons for UKA revisions are pain, loosening of a tibial component, and loosening of a femoral component [8]. The indications for revisions of the cementless Oxford implant have not been separately assessed [8]. Twenty-three tibial fractures were reported to the NZJR, but it is unknown whether these cases were related to the use of cementless UKAs or not. Six tibial fractures associated with the use of the cementless Oxford implant have been reported to FAR thus far (nine percent of all revisions, 0.5% of all operations). It seems that the risk of a perioperative tibial fracture when using the cementless Oxford method is small, although higher than with the cemented Oxford 3 implant (one percent of all revisions, 0.0009% of all operations). Due to the poor accuracy of reported indications for revision to the FAR, the true incidence of perioperative fractures may be higher.

In a systematic literature review of 10 papers (1199 knees) on the outcome of cementless UKA, 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 OA in the retained component (11 revisions, 0.9% of all operations), followed by bearing dislocation (eight revisions, 0.7% of all operations), and loosening of the tibial component (six revisions, 0.4% of all operations) [21]. Progression of OA in the lateral component is a major reason for UKA failure in the longer term. However, the follow-up time after implantation of the cementless Oxford device in the current study was short when compared with the review (median 2.1 years in the current study, median five years in the review). Furthermore, progression of lateral OA was, unfortunately, not separately assessed as a reason for revision in the current FAR data contents. This flaw will be revised in the following FAR data contents update. Based on the review data, periprosthetic tibial fractures are an uncommon complication of cementless UKA surgery [21]. However, these data were from specialised clinics only. Data from the current study were population-based and included all UKA surgeons in Finland, which partially invalidated the comparison. Therefore, the overall revision rate in this population-based study (64 revisions, 1076 cementless Oxfords) was slightly higher than in the review (48 revisions, 1199 cementless UKAs).

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In an earlier report based on FAR data from 1985 to 2011, it was stated that the 10-year survival of the cementless Oxford UKA was 83% (approximated from the figure) [6]. These earlier data are in accordance with the current results based on 2005–2015 data. However, in an earlier report, it was not possible to separately assess cementless and cemented Oxfords. The popularity of the cementless Oxford method markedly grew after publication of the previous study in 2014 [6]; therefore, reporting implant survival of both fixation methods mixed with an earlier study was probably unbiased. The most common reason for revision in the earlier study based on FAR data was 'aseptic loosening' (46.8%), followed by 'other reason' (35%). Although the accuracy of recording reasons for revision in the FAR registry was unsatisfactory, it seems that aseptic loosening as a major cause of failure of the cementless Oxford implant has decreased in Finland.

To conclude, in the short term, use of the cementless Oxford implant is associated with increased survival compared with the cemented Oxford 3. However, overall survival of both UKA types is still inferior to contemporary cemented TKAs.

Conflict of interest

Each author certifies that he has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licencing arrangements) that might pose a conflict of interest in connection with the submitted article.

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The local IRB approved the human protocol for this investigation, and each author certifies that all investigations were conducted in conformity with ethical principles of research. The research permission number from the National Institute for Health and Welfare is Dnro THL/506/5.05.00/2016. This study is the result of close teamwork. All authors participated in the planning and design of the study and interpretation of the results. AR performed the statistical analyses. JK and KM were responsible for writing the manuscript. All authors contributed to the final version of manuscript and approved it. This research did not receive any specific funding from public, commercial, or not-for-profit actors.

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