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Did a New Design of the Oxford Unicompartmental Knee Prosthesis Result in Improved Survival? A Study From the Norwegian Arthroplasty Register 2012-2021

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Abstract

Background Unicompartmental knee arthroplasty (UKA) has generally shown higher revision rates than TKA, and this is particularly true for the femoral component. A twin-peg femoral component (Oxford Partial) has replaced the single-peg version (Oxford Phase III) of the widely used Oxford medial UKA, with the aim of improving femoral component fixation. The introduction of the Oxford Partial Knee also included a fully uncemented option. However, there has been relatively little evidence regarding the effect of these changes on implant survival and revision diagnoses from groups not associated with the implant design.

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Ethical approval was not sought for the present study.
This work was performed at Haugesund Hospital for Rheumatic Diseases in Haugesund, Norway and at The Norwegian Arthroplasty Register in Bergen, Norway.

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Questions/purposes Using data from the Norwegian Arthroplasty Register, we asked: (1) Has the 5-year implant survival (free from revision for any cause) improved with the medial Oxford unicompartmental knee after the introduction of new designs? (2) Did the causes of revision change between the old and new designs? (3) Is there a difference in risk for specific revision causes between the uncemented and cemented versions of the new design?

Methods We performed a registry-based observational study using data from the Norwegian Arthroplasty Register, a nationwide, mandatory and governmental registry with a high reporting rate. Between 2012 and 2021, 7549 Oxford UKAs were performed, and 105 were excluded due to combinations of the three designs, lateral compartment replacement, or hybrid fixation, leaving 908 cemented Oxford Phase III single-peg (used from 2012 to 2017), 4715 cemented Oxford Partial twin-peg (used from 2012 to 2021), and 1821 uncemented Oxford Partial twin-peg (used from 2014 to 2021), UKAs available for the analysis. The Kaplan-Meier method and Cox regression multivariate analysis were used to find the 5-year implant survival and the risk of revision (hazard ratio), when adjusting for age, gender, diagnosis, American Society of Anesthesiologists grade, and time period. The risk of revision for any cause and the risk of revision for specific causes were compared, first for the older with the two new designs, and second for the cemented with the uncemented version of the new design. Revision was defined as any operation exchanging or removing implant parts.

Results The 5-year Kaplan-Meier overall implant survival (free from revision for any cause) for the medial Oxford Partial unicompartmental knee did not improve over the study period. The 5-year Kaplan-Meier survival was different (p = 0.03) between the groups: it was 92% (95% confidence interval [CI] 90% to 94%) for the cemented Oxford III, 94% (95% CI 93% to 95%) for the cemented Oxford Partial, and 94% (95% CI 92% to 95%) for the uncemented Oxford Partial. However, the overall risk of revision during the first 5 years was not different between the groups (Cox regression HR 0.8 [95% CI 0.6 to 1.0]; p = 0.09 and 1.0 [95% CI 0.7 to 1.4]; p = 0.89 for the cemented Oxford Partial and the uncemented Oxford Partial, respectively, compared with cemented Oxford III [HR 1]). The uncemented Oxford Partial had a higher risk of revision for infection (HR 3.6 [95% CI 1.2 to 10.5]; p = 0.02) compared with the cemented Oxford III. The uncemented Oxford Partial had a lower risk of revision for pain (HR 0.5 [95% CI 0.2 to 1.0]; p = 0.045) and instability (HR 0.3 [95% CI 0.1 to 0.9]; p = 0.03) compared with the cemented Oxford III. The cemented Oxford Partial had a lower risk of revision for aseptic femoral loosening (HR 0.3 [95% CI 0.1 to 1.0]; p = 0.04) compared with the cemented Oxford III. When comparing the uncemented and cemented versions of the new design, the uncemented Oxford Partial had a higher risk of revision for periprosthetic fracture (HR 15 [95% CI 4 to 54]; p = 0.001) and infection within the first year (HR 3.0 [95% CI 1.5 to 5.7]; p = 0.001) than the cemented Oxford Partial.

Conclusion Considering that we found no difference in overall risk of revision during the first 5 years but we found a higher risk of revision for infection, periprosthetic fracture, and higher per implant cost, we currently would recommend against the use of uncemented Oxford Partial over the cemented Oxford Partial or the cemented Oxford III.

Level of Evidence Level III, therapeutic study

Introduction

The main problem with unicompartmental knee arthroplasty (UKA) survival has been the risk of revision for aseptic loosening. Data from the Norwegian Arthroplasty Register shows that aseptic loosening was the main cause of revision for UKA (81%) at 10-year follow-up [6, 8]. Other registries, including the Australian and Swedish arthroplasty registries, have also shown that this is a global problem [2, 19]. Previous studies have shown that between 25% and 50% of aseptic loosening in UKAs involve the femoral component [8, 13]. The Oxford UKR (Zimmer Biomet) is one of the most commonly used UKA implants worldwide [2, 15, 16, 19]. To address femoral loosening and improve survival, the implant was changed. The Oxford Phase III femoral component is, like its predecessors (the Phase I and II), spherical with only one anchoring peg for insertion into the femoral condyle. The new Oxford Partial femoral component was designed with two pegs to achieve more stable fixation, taking advantage of the two femoral holes used for the cutting guide. To support an extra peg, the femoral component was advanced 15° anteriorly (of a sphere), resulting in a larger surface area for support (Fig. 1). The Oxford Microplasty instruments were introduced in Norway in 2012, along with this new version of the Oxford UKA, allowing for implantation of the femoral component in a slightly more flexed position, which is believed to reduce shear forces and the risk of anterior impingement.

The Oxford Partial UKA was introduced in some countries in 2004, but it was not widely available in Norway until 2012. In the Norwegian Arthroplasty Register, the cemented Oxford Partial has been reported since 2012, the uncemented Oxford Partial since 2014, and the Oxford Microplasty instruments have primarily been used for Oxford Partial UKAs in our registry. The difference between the cemented Oxford Partial and uncemented Oxford Partial designs is the hydroxyapatite-coated titanium mesh of the backside surfaces of the uncemented prosthesis, with the tibial components and the polyethylene bearings largely unchanged. One cohort study reported good midterm results (98% survival after 9 years) for the twin-peg cemented Oxford Partial [23]; another cohort

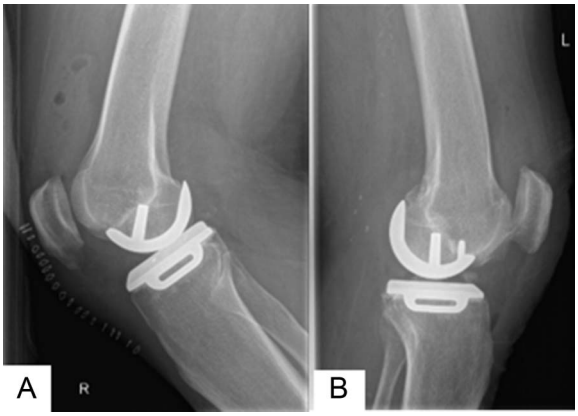

Fig. 1 **(A)** A single-peg cemented Oxford III is shown here. (**B**) This figure demonstrates a twin-peg cemented Oxford partial implant.

study [9] found 97% 5-year survival for the uncemented Oxford Partial. A study from the National Joint Registry for England, Wales, Northern Ireland, and the Isle of Man published in 2020 a matched comparison between the two cemented Oxford UKRs; the results showed an improved survival for the new twin-pegged femoral component (96.2% versus 94.8% 5-year survival) [14]. It is important that new technology and new implants are introduced to the market with care and ultimately to the benefit of our patients [1].

As the Oxford UKA is the most widely used UKA implant worldwide, improved survival would have an impact on many patients. The results with the new design have been promising in a cohort study and in the National Joint Registry (NJR) [15, 23]. However, it is uncertain whether the new design represents an improvement compared with the Oxford III because in many countries, the Oxford Partial knee was introduced with both cemented and uncemented versions along with the Oxford Microplasty instruments. Furthermore, the uncemented version of the new design may have introduced new problems and risks to be assessed, through analyses of causes for revision.

Using data from the Norwegian Arthroplasty Register, we asked: (1) Has the 5-year implant survival (free from revision for any cause) improved with the medial Oxford UKA after the introduction of the new designs? (2) Did the causes of revision change between the older and newer designs? (3) Is there a difference in revision causes between the uncemented and cemented versions of the new design?

Patients and Methods

Study Design and Setting

This study analyzed arthroplasty data from the Norwegian Arthroplasty Register, which covers a population of about 5.2 million people. Although the NJR reports have been promising for the new design, the data in that registry contains data from many high-volume surgeons involved in implant development. The results from a country like Norway, with a high reporting rate and less influence from the designing surgeons, would be valuable. Furthermore, results from different registries may vary due to different surgical traditions, indications for surgery (primary and revision), demographics, economic funding, and public health systems. All these factors will influence the survival and revision causes. If the results from the NJR can be reproduced and verified in other registries, they will be viewed as more valid for the average orthopaedic surgeon worldwide.

Improvements in surgical technique and more experience with UKAs over the years may have influenced the results. However, if the improvement was not directly related to the new design, there would be no reason to replace the Oxford III with the Oxford Partial knee. To detect what variables may have influenced survival, an analysis of the revision causes needs to be done.

Moreover, the two variants of the new design (cemented and uncemented) seem unnecessary if they have similar results. In Norway, the cost is higher for the uncemented variant, and this extra cost should be justified. If unexpected risks and challenges occur, the presumed benefit of improved fixation with cementless designs may be reduced by added complications.

Data Sources

The data from the Norwegian Arthroplasty Register included patient-, implant-, and surgery-specific information. After each surgical procedure, the surgeon completed a standard form and forwarded it to the register. The surgeon recorded the implant catalogue numbers of all implant parts on the form [8]. The registration completeness exceeds 95% for primary operations and is greater than 93% for revisions [6, 16]. We extracted anonymized data from the Norwegian Arthroplasty Register, including all primary Oxford UKAs in a 10-year period between January 2012 and December 2021 (Fig. 2). We chose 2012 as the starting year because the twin-peg Oxford femoral component UKA was first reported to the registry that year.

Patients

After excluding lateral Oxford UKAs, hybrid fixation, and combined implantations (old and new implants) and patients with missing data/lost to follow-up, we were left with 908 medial cemented Oxford III, 4715 cemented

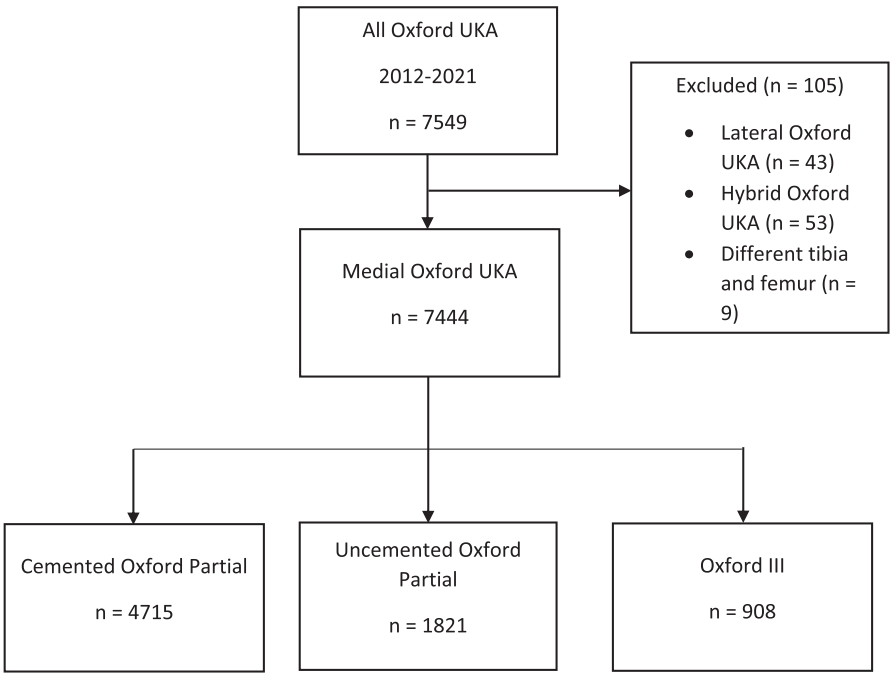

Fig. 2 After applying our exclusion criteria, 7444 Oxford UKAs performed from 2012 to 2021 were included in our analysis.

Oxford Partial (twin-peg), and 1821 uncemented Oxford Patrial UKAs eligible for study inclusion (Fig. 2). Median follow-up was 8 years for the cemented Oxford III, 4 years for the cemented Oxford Partial, and 3 years for the uncemented Oxford Partial. The longer follow-up time for the cemented Oxford III was because it was used until 2017, when it was replaced by the new Oxford Partial prostheses. Use of the cemented Oxford III and the cemented Oxford Partial implant overlapped from 2012 to 2017. Use of the uncemented Oxford partial was first reported in 2014, but in a relatively low number the first 2 years. The cemented Oxford Partial was reported during the entire study period but with lower numbers the first 3 years. To avoid confounding due to different follow-up times, the data were censored after 5 years, with 5 years of median follow-up for the cemented Oxford III, 4 years for the cemented Oxford Partial, and 3 years for the uncemented Oxford Partial.

Descriptive Data

The mean age of patients was 65 ± 9 years for the cemented Oxford III and 66 ± 9 years for both the cemented and uncemented Oxford Partial, but the gender distribution differed between the groups. There were slightly more women than men for the Oxford III, but the opposite was true for the newer cemented and uncemented Oxford Partial. The American Society of Anesthesiologists (ASA) classification also differed marginally between the groups, where the Oxford III group reported a higher percentage (89%) of ASA I classification than the two other designs (84% and 85%). These marginal differences between the groups were adjusted for in the analyses, and they were considered too small to have influenced the main results beyond the adjustments (Table 1). The primary indication for surgery was osteoarthritis (96% [7117 of 7444]).

Primary and Secondary Study Outcomes

Our primary study goal was to analyze whether the redesigned Oxford Partial prostheses (cemented and uncemented) had better overall survival compared with the older cemented Oxford phase III. To achieve this, we estimated the 5-year Kaplan-Meier survival and an adjusted Cox regression HR, comparing the older cemented Oxford III with the cemented and uncemented Oxford Partial, adjusting for age, gender, diagnosis (osteoarthritis/other joint disease), ASA grade (ASA I/ASA II/ASA III+), and time period (2012 to 2016/2017 to 2021).

Our secondary study goals were to assess (1) whether the risks of revision causes differ when moving from the old to the new designs and (2) whether the risks of revision

Table 1. Demographics

Covariate	Oxford III cemented (n = 908)	Oxford Partial cemented (n = 4715)	Oxford Partial uncemented (n =1821)	p value	p value (Oxford III excluded)
Gender				0.02	0.48
Female	52 (471)	47 (2209)	48 (871)		
Male	48 (437)	53 (2506)	52 (950)		
Age at surgery	65 ± 9	66 ± 9	66 ± 9	< 0.001	0.35
Primary diagnosis				0.001	0.007
Primary OA	93 (852)	95 (4500)	97 (1765)		
Other	6 (56)	5 (215)	3 (56)		
ASA grade				< 0.001	0.21
I	89 (795)	84 (3873)	85 (1514)		
II	11 (10)	17 (763)	15 (271)		
III or above					
Year of surgery				< 0.001	< 0.001
2012-2016	100 (907)	39 (1824)	14 (247)		
2017-2021	0 (1)	61 (2891)	86 (1574)		
Year of surgery					
2012	330	106	0		
2013	232	204	0		
2014	198	373	7		
2015	129	513	59		
2016	18	628	181		
2017	1	543	296		
2018	0	564	399		
2019	0	577	368		
2020	0	597	200		
2021	0	610	311		

Data presented as % (n) or mean ± SD. p values were determined using a chi-square test for binary/categorical variables and one-way ANOVA for continuous variables.

causes vary between the cemented Oxford Partial and uncemented Oxford Partial designs.

Variables

Revision was defined as surgery with removal, exchange, or addition of one or more prosthesis components. The surgeons could report one or more of the following reasons for revision: loose femoral component, loose tibial component, dislocation, instability, malalignment, deep infection, fracture, pain, worn or broken polyethylene, or progression of OA; surgeons were also allowed to choose their own descriptions. All reported revision causes were included in the analyses, with no censoring or hierarchical selection. If more than one cause of revision was given, they were all included in the subanalyses for specific revision causes to avoid underestimation of the individual revision causes due to a hierarchy. Confounding by competing risks was additionally tested by Fine and Gray analyses and did not alter the results.

Ethical Approval

Ethical approval was not sought since the Norwegian Arthroplasty Register has a concession from the Norwegian Data Inspectorate to collect and analyze data based on written consent from the patients. The registration of data and the study was performed confidentially on patient consent and according to the Norwegian Data Protection regulations (reference number 03/00058-20/CGN) and Norwegian and EU data protection rules. Data may be accessible upon application to the Norwegian Arthroplasty Register. The Norwegian Arthroplasty Register fully financed the study.

Statistical Analysis

For our primary outcome, we used the Kaplan-Meier method to estimate cumulative survival. Survival was defined as an implant free of any revision where parts were exchanged or removed. Statistical significance was tested with a log-rank test. Furthermore, an HR was calculated using a Cox regression multivariate analysis, adjusting for age, gender, ASA classification (ASA I/ASA II/ASA III+), diagnosis (osteoarthritis/other joint disease), and time period (2012 to 2016/2017 to 2021), to compare risk of revision for all causes. For our secondary outcomes, an adjusted Cox regression analysis for each specific revision cause was performed. Firstly, we compared the cemented Oxford Partial and uncemented Oxford Partial UKAs with the cemented Oxford III UKAs (Oxford III as reference). Secondly, we compared the uncemented Oxford Partial with the cemented Oxford Partial UKAs. Proportional hazards were tested and found valid for the overall survival analysis. For the specific revision causes, we performed a Fine and Gray analysis and checked it against the Cox regression analysis. If the results differed, the Fine and Gray estimate was reported. For demographics, p values were determined using a chi-square test for binary/categorical variables and one-way ANOVA for continuous variables.

All statistical analyses were performed using IBM SPSS version 22.0 (IBM Corp) and STATA version 17.0 (STATA Corp). All p values less than 0.05 were considered significant, with a presented 95% confidence interval (CI).

Results

Has Survival of the Medial Oxford Unicompartmental Knee Improved With the New Design?

Survivorship did not improve with the new design of the medial Oxford UKA. Overall 5-year survival for the cemented Oxford Partial was 94% (95% CI 93% to 95%) compared with 94% (95% CI 92% to 95%) for the uncemented Oxford Partial and 92% (95% CI 90% to 94%; p = 0.03) for the cemented Oxford III (Fig. 3). We found no difference for the overall risk of revision comparing the cemented and uncemented Oxford Partial with the cemented Oxford III in the reported time period, 2012 to 2021, when adjusting for age, gender, diagnosis, ASA classification, and time periods (Table 2). However, for the uncemented Oxford Partial, the overall risk of revision was lower than the older design cemented Oxford III from 1 to 5 years of follow-up (Table 2).

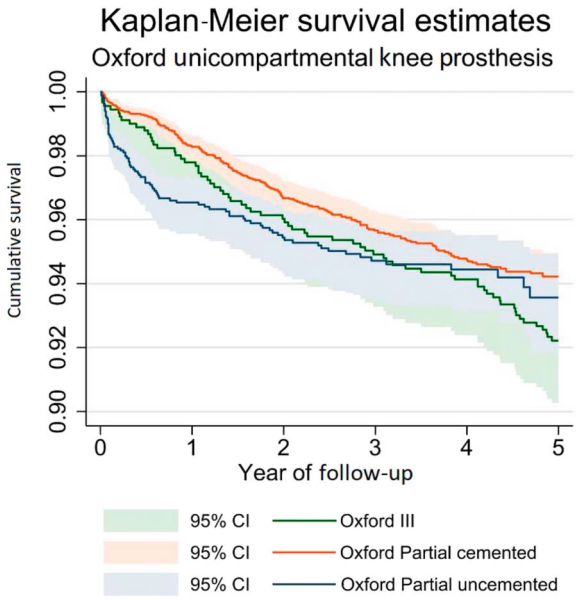

Fig. 3 Five-year survival for the cemented Oxford Partial was 94%, it was 94% for the uncemented Oxford Partial, and it was 92% for the cemented Oxford III. A color image accompanies the online version of this article.

Did the Indications for Revision Change Between the Older and Newer Design?

The main indications for revision changed with the introduction of the new design. The risk of revision for femoral loosening was lower for the cemented Oxford Partial compared with the cemented Oxford III (HR loosening 0.3 [95% CI 0.1 to 1.0]; p = 0.04). The uncemented Oxford Partial had a higher risk of revision for infection (HR 3.6 [95% CI 1.2 to 10.5]; p = 0.02) and a lower risk of revision for pain (HR 0.5 [95% CI 0.2 to 1.0]; p < 0.05) and instability (HR 0.3 [95% CI 0.1 to 0.9]; p = 0.03 (Table 2).

Did the Indications for Revision Differ Between the Uncemented and Cemented Designs?

The revision causes differed between the cemented Oxford Partial and the uncemented Oxford Partial designs. When comparing the uncemented Oxford Partial with the cemented Oxford Partial (HR 1), we found a higher risk of revision for periprosthetic fracture (HR 15 [95% CI 4 to 54]; p < 0.001) and infection up to 1 year (HR 3.0 [95% CI 1.5 to 5.7]; p = 0.001, and polyethylene wear the first 2.5 years (HR 7.8 [95% CI 1.5-40]; p = 0.02, for the uncemented version (Table 3).

Discussion

A primary issue with UKA survival has been the risk of aseptic loosening, particularly of the femoral component.

Table 2. Cox multivariate regression analysis of the three design options for the Oxford medial UKA

	Oxford III cemented (n = 908)		Oxford Partial cemented (n = 4715)			Oxford Partial uncemented (n = 1821)		
Diagnosis of revision	Number	HR	Number	HR (95% CI)	p value	Number	HR (95% CI)	p value
All diagnoses (overall)[a]	71	1	205	0.8 (0.6-1.0)	0.09	89	1.0 (0.7-1.4)	0.89
All diagnoses year 0-1	31	1	78	0.8 (0.5-1.4)	0.47	61	1.7 (0.9-3.1)	0.08
All diagnoses year 1-5	50	1	127	0.8 (0.5-1.1)	0.16	28	0.5 (0.3-0.9)	0.02
Infection[a]	5	1	30	1.6 (0.6-4.3)	0.34	20	3.6 (1.2-10.5)	0.02
Infection year 0-1	4	1	22	1.4 (0.5-4.2)	0.56	20	4.1 (1.3-13.5)	0.02
Periprosthetic fracture[b]	0		3	1		15	15 (4-54)	< 0.001
Polyethylene wear/damaged	3	1	4	0.3 (0.1-1.6)	0.17	7	1.4 (0.2-8.6)	0.69
Femoral loosening	8	1	8	0.3 (0.1-1)	0.04	1	0.2 (0.0-1.5)	0.11
Tibial loosening[a]	10	1	29	0.9 (0.4-1.9)	0.80	6	0.7 (0.2-2.2)	0.56
Tibial loosening year 0-1.5	2	1	15	2.1 (0.5-9.7)	0.34	5	2.3 (0.4-13)	0.37
Tibial loosening year 1.5-5	8	1	14	0.6 (0.2-1.6)	0.31	1	0.2 (0.0-2)	0.18
Progression of osteoarthritis	16	1	45	1.0 (0.5-1.8)	0.91	6	0.4 (0.1-1.2)	0.10
Pain	30	1	65	0.7 (0.5-1.2)	0.19	12	0.5 (0.2-1.0)	0.045
Instability	12	1	39	0.5 (0.2-1.2)	0.11	10	0.3 (0.1-0.9)	0.03
Malalignment	9	1	17	0.4 (0.2-1.1)	0.07	5	0.3 (0.1-1.2)	0.10
Luxation of polyethylene	6	1	20	0.7 (0.2-1.8)	0.41	15	1.2 (0.4-3.8)	0.79
Other	7	1	32	1.2 (0.5-3.1)	0.69	17	1.7 (0.6-4.9)	0.35

Risk of revision for specific indications for revision and overall risk of revision (Cox – adjusted for gender, age, diagnosis, ASA, and time period).
[a]Separate time periods to fulfill proportional hazards assumption.
[b]Oxford III excluded from analysis.

Table 3. Cox multivariate regression analysis of the two newer design options for the Oxford medial unicompartmental knee replacement

	Oxford Partial cemented (n = 4715)		Oxford Partial uncemented (n = 1821)		
	Number	HR	Number	HR (95% CI)	p value
Periprosthetic fracture	3	1	14	15 (4-54)	< 0.001
Polyethylene wear/damaged[a]	4	1	7	4.7 (1.3-17)	0.02
Polyethylene wear/damaged year 0-2.5	2	1	6	7.8 (1.5-40)	0.02
Infection[a]	30	1	20	2.2 (1.2-4.1)	0.01
Infection year 0-1	22	1	20	3.0 (1.5-5.7)	0.001
Loosening femur	8	1	1	0.5 (0.1-3.9)	0.47
Loosening tibia	29	1	6	0.8 (0.3-2.0)	0.59
Progression of osteoarthritis	45	1	6	0.4 (0.2-1.1)	0.07
Pain	65	1	12	0.6 (0.3-1.2)	0.15
Instability	39	1	10	0.6 (0.3-1.3)	0.20
Malalignment	17	1	5	0.8 (0.3-2.1)	0.60
Luxation of polyethylene	20	1	15	1.8 (0.9-3.7)	0.11
Other	32	1	17	1.4 (0.7-2.6)	0.32

Risk of revision for specific diagnoses of revision and overall risk of revision (Cox – adjusted for gender, age, diagnosis, ASA, and time period).
[a]Not valid due to proportional hazard assumption not fulfilled.

Data from the Norwegian Arthroplasty Register shows that aseptic loosening was the main cause of revision for UKA at 10-year follow-up [8]. One cohort study [23] and a registry study [14] have suggested that the overall survival has improved with the new design of the Oxford unicompartmental knee, and there was hope that the uncemented version of the new design had diminished the problem of radiolucencies and aseptic loosening. This study shows that the design changes of the Oxford UKA changed the causes for revision without improving the overall survival. The ability to identify the effect of changes in implant designs is an important task of well-established national registries, and data from a country with a high reporting rate and little influence from the designers/manufacturers is especially valuable when evaluating new or redesigned implants. Other registries have shown that revision for implant loosening is a global problem, and previous studies have shown that 25% to 50% of aseptic loosening in UKAs involve the femoral component [8, 13]. We analyzed data from the Norwegian Arthroplasty Register to compare the newer design cemented and uncemented Oxford partial UKA to the previous Oxford Phase III design. We found no difference in the overall revision risk between these three implants. When comparing the specific reasons for revision, we found that revisions for aseptic loosening of the femoral component were higher for the cemented single-peg Oxford III compared with the twin-peg cemented Oxford Partial. Revision risk for pain was lower for the uncemented Oxford Partial compared with the Oxford III. Periprosthetic fracture as a revision cause was higher for the uncemented Oxford Partial compared with cemented Oxford Partial. This latter finding is alarming with respect to the causes for early failure in the uncemented Oxford Partial group. The cemented Oxford Partial has replaced the older cemented Oxford III in the market. It has similar 5-year survival to the cemented Oxford III, and in this study, we found no alarming new causes of revision for the cemented Oxford Partial knee. Additionally, in Norway, the uncemented version is more expensive, and with the differing risks of revision for the uncemented implant in mind, the cemented version should be preferred.

Limitations

One important limitation to this study is the relatively short follow-up with different median follow-up times for the groups. The cemented Oxford III implants have had more time to fail, and certain causes of revision such as aseptic loosening, which are expected to increase with time, might be more often reported in this group. To minimize this confounder and achieve more similar follow-up times, the inclusion of data was stopped at 5 years of follow-up. The difference in revision causes reported, such as fracture and infection, occur early in the period, hence they will be detected despite the short follow-up. Furthermore, prostheses and surgical technique may improve with time and volume. However, this possible bias is likely to have impacted all three groups equally, and there is no reason to believe that one group would be more affected than the other.

The multiple testing for different revision causes may have introduced the risk of a statistical Type I error, weakening our results. On the other hand, the strength of registry studies is the ability to detect and analyze relatively rare events, like revisions. Due to the serious implications for patients, these rare occasions must be addressed and surgeons must be alerted that they exist. Gender must also be considered in our study results, because one cannot assume that a finding drawn from a population of men and women would apply equally for men and women separately. In this study, the only outcome measure is revision, which is a crude measure, but gender was adjusted for in the analyses to reduce this bias. PROMs could identify patients who are doing poorly but who chose not to undergo another surgery; however, PROMs were not available in the Norwegian Arthroplasty Register for these implants in this period. Revision as the only endpoint is a limitation for all registries because of the issue with patients who may have pain due to a loose implant but who are not candidates for revision surgery or who choose not to undergo revision surgery. This does not disqualify the findings here because there is no reason to think it more likely in one group than another.

We do not have any data on the potential learning curve for the newest uncemented Oxford Partial, which represents a limitation to this study. Another limitation is that surgeons can report more than one revision cause without classifying which cause is the most plausible reason for implant failure. Again, this limitation would apply equally to all groups but also allows for more granularity in reporting of the revision indications. The low number of revisions in this study may be the reason why we were not able to show statistically significant differences for the various revision causes. Furthermore, the Oxford Microplasty instrumentation became available in 2011 and was mostly used for cemented and uncemented Oxford Partial but also for some of the cemented Oxford III operations throughout the study period. This may have influenced the results in favor of the newer designs, since the new instrument set aids in more accurate placement of the components, with a modified implantation technique. Conversely, there is always a learning curve with new instrumentation.

Has Survival of the Medial Oxford Unicompartmental Knee Improved With the New Design?

We found no difference in the overall revision risk between the three Oxford UKA implants we analyzed. The

unadjusted survival estimates from the Kaplan-Meier analysis showed a statistically but not clinically significant difference. When adjusting for age, gender, diagnoses, ASA class, and time, the Cox regression hazard ratios showed no difference. A register-based study with a large number of patients that compared single-peg with twin-peg Oxford UKAs in a matched comparison similarly showed no difference in the overall revision risk at 5 years between cemented Oxford Partial and cemented Oxford III [14]. A cohort study found better survivorship for the cemented twin-peg Oxford partial when compared with the cemented single-peg Oxford [23]. Based on these findings, we recommend the use of the cemented Oxford Partial implant, which has replaced the single-peg cemented Oxford III, over the more costly uncemented Oxford Partial. For the first 1 to 5 years, however, the uncemented Oxford Partial had a lower risk of revision overall compared with the older cemented Oxford III; this result might leave some optimism and is the reason why further research with longer follow-up is needed.

Did the Indications for Revision Change Between the Older and Newer Design?

We found that the twin-peg cemented Oxford Partial had a lower risk of revision for femoral loosening compared with the single-peg Oxford III. This finding supports previous results that the combination of microplasty instruments and a new twin-peg design creates a stable situation with less chance of revision for a loose femoral component. Two cadaver studies also showed better strength of fixation for the twin-peg femoral component [17, 18]. The uncemented Oxford Partial had more revisions for periprosthetic fracture and infection but a lower risk of revision for pain than the Oxford III. All the cemented Oxford UKAs in this study utilized antibiotic bone cement (ABC), which slowly releases antibiotics in the early period after surgery. Most cemented arthroplasties in Norway use ABC. The fact that the uncemented prosthesis only get antibiotics intravenously around the surgery could perhaps explain the difference in infection rate. To elaborate this infection risk further, large registry or randomized controlled studies must be performed. The cemented technique might be preferred over the cementless because it is less traumatic to the bone. The impaction of bone and pressfit technique of the uncemented design might introduce a risk of fracture.

The new Oxford Microplasty instruments were introduced along with the cemented Oxford Partial and uncemented Oxford Partial to improve the reproducibility of implant positioning and to minimize tibial bone resection. Two studies comparing Oxford Microplasty to conventional instrumentation showed a reduced risk of malalignment of the femoral component and more accurate tibial bone resection, with less bone loss [21, 22]; another study reported reduced revision rates with the new instrumentation [20]. This new instrument set, mostly used for the newest designs, may have influenced the results in favor of the Oxford partial prostheses.

The causes for revision indicated by the surgeon may have changed over time along with the design changes. Previously, the revision indication of pain was more acceptable as a sole reason for revision. One study showed that the results after revision for pain alone had less favorable outcomes than revision for a known cause of pain [11]. Our study showed that the uncemented Oxford Partial knee had a lower risk of revision for pain. This finding might be because the uncemented Oxford Partial had been included later in the observation period.

Did the Indications for Revision Differ Between the Uncemented and Cemented Designs?

Periprosthetic fracture as a revision cause was more common in the uncemented Oxford Partial compared with the cemented Oxford Partial, which is supported by previous studies [12, 13]. Nevertheless, a recent meta-analysis concluded that good results can be achieved for uncemented UKAs, comparable to cemented prostheses, when surgeons are aware of the different risk factors of causing fracture, like excessive press fit (interference fit) and impaction technique [5]. The interference fit may introduce an additional risk and be less forgiving of surgical errors, especially for patients at higher risk of periprosthetic fracture. One small study suggested techniques for intraoperative testing of the bone quality as a tool to select fixation methods [7]. Hiranaka et al. [10] found an increased fracture risk in patients with very small tibial components; the authors recommended cemented fixation for this group. Consequently, the implantation of an uncemented tibial component may be a more challenging procedure, requiring more surgical experience and skill. The risk of fracture with uncemented implants needs to be further investigated. Badawy et al. [3, 4] showed that in general, the results for UKAs are better for hospitals with a higher patient volume. Thus, for low-volume hospitals and surgeons, the cemented implant might be the best option. However, data on surgeon case load and experience were not reported to the Norwegian Arthroplasty Register. There was a higher revision risk for polyethylene wear/damage the first 2.5 years for the uncemented Oxford Partial compared with the cemented version, and it was more common that this reason for revision was reported with polyethylene luxation. Polyethylene damage could have been a consequence of the luxation. Again, this would lead the authors here to recommend use of the cemented Oxford Partial, given that

it can be more widely used, independent of bone quality, size of bone, gender, or age of the patient.

Conclusion

This study did not find any overall differences in the revision risk at 5 years between the three Oxford unicompartmental knee designs. We found an improvement with less risk of femoral loosening for the cemented Oxford Partial compared with the older Oxford III, but we found more periprosthetic fractures and infections for the uncemented Oxford Partial knee. The cemented Oxford Partial appears to be an acceptable replacement for the previous Oxford III at 5 years and should be preferred over the uncemented version. Future studies should focus on reasons for infection and fracture associated with the use of an uncemented implant.

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