Title Page (Unblinded)

The effect of surgeon caseload on the relative revision rate of cemented and cementless Unicompartmental Knee Replacements: An analysis from the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man

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ABSTRACT

Background: Unicompartmental knee replacement (UKR) has worse revision rates than total knee replacement, despite offering other substantial benefits. Registries suggest revision rates for cementless UKR are less than cemented. It is not known how much of this is due to the implant, or other factors like more high-volume surgeons using cementless. We aimed to determine the effect of surgeon caseload on the revision rate of matched cemented and cementless UKRs.

Methods: From 40,552 Oxford UKR (30,814 cemented, 9708 cementless) recorded in the National Joint Registry,14,814 were propensity score matched (7,407 cemented, 7,407 cementless). Surgeons were categorized in low (<10 cases/year), medium (10 to <30 cases/year) and high volume (≥30 cases/year) groups. The effect of caseload on the relative risk of revision was assessed using cox regression.

Results: The ten-year survival for unmatched cementless and cemented UKR were 93.3% (95% CI=89.8–95.7) and 89.1% (CI=88.6-89.6) respectively, with the difference being significant (hazard ratio(HR) 0.59, p<0.001). Cementless UKRs had a greater proportion of high volume surgeon users than cemented (30.4% compared to 15.1%). Following matching the ten-year survivals were 93.2% (CI=89.7-95.6) and 90.2% (CI=87.5–92.3), which were still significantly different (HR 0.76, p=0.002).

The ten-year survival for matched cementless and cemented UKR for low volume surgeons were 86.8% (CI=73.6-93.7) and 81.8% (CI=73.0-88.0), for medium were 94.3% (CI=92.2-95.9) and 92.5% (CI=89.9-94.5) and for high were 97.5% (CI=96.5-98.2) and 94.2%

(CI=90.8-96.4). The revision rate for cementless was lower in all caseloads (HR 0.74, 0.79, 0.80 respectively).

Conclusions: Cementless fixation decreased the revision rate by about a quarter whatever the surgeon caseload. Caseload had a profound effect on survival: Low volume surgeons have a high revision rate with cemented or cementless fixation, **so should consider stopping UKR or doing more**. High volume surgeons using cementless UKR have a ten-year survival of 97.5% **which is similar to the best TKR.**

Level of evidence: II

INTRODUCTION

The two main treatment options for end stage knee osteoarthritis which has failed to respond to conservative management are total knee replacement (TKR) and unicompartmental knee replacement (UKR). UKR offers substantial benefits over TKR[1-3], but joint registries report higher revision rates [4-6].

Surgeon caseload or volume is defined as the number of operations a surgeon performs per year and effects implant revision rates, with low volume surgeons having much higher revision rates than high volume surgeons[7]. This is particularly marked for UKR and is likely an important reason why UKR **revision rates are so high**. In the UK the commonest surgeon caseload for UKR is 1 case/yr and the average is 5 cases/yr, compared to 34 cases/yr for TKR[7].

The Phase 3 Oxford (Zimmer Biomet, Swindon, United Kingdom) is the most commonly used partial knee system[8]. Leading revision indications include aseptic loosening and pain[9], and therefore a cementless replacement was implanted. The only modifications are a porous titanium/hydroxyapatite coating and an extra femoral peg. Therefore, it is an ideal implant to compare fixation.

Randomized studies have shown reduced radiolucent lines incidence with cementless UKR compared to cemented[10]. These studies were underpowered to compare revision rates. Large cementless Oxford UKR cohort studies report low revision rates[11, 12], but are not different from similar large cemented studies[13, 14]. In contrast the New Zealand joint registry (NZJR) reports lower revision rates for the cementless Oxford[6] UKR. Although the cementless does appear to be a better implant[15] another possible explanation for its improved results is that experienced high volume surgeons who obtained good results with UKR have predominantly changed to use cementless components and low volume surgeons, who typically obtained worse results, have continued to use cemented components. There are concerns that cementless fixation is less forgiving than cemented **with regard to obtaining stable fixation. Therefore low volume surgeons might actually get worse UKR results if they changed to cementless fixation**. It is not known whether the relative performance of cemented and cementless UKR is influenced by surgeon caseload.

The National Joint Registry for England, Wales, Northern Ireland and Isle of Man (NJR) is the largest arthroplasty register[4] but doesn't report UKR results by fixation type. We analysed NJR data to determine the number of cemented and cementless UKR being used and to determine their survival. In addition, we used NJR data to assess the effect of surgeon caseload on the relative revision rate of cemented and cementless Oxford UKRs.

MATERIALS AND METHODS

A retrospective observational study was performed using NJR records[4]. The NJR collects data on patient (including age, sex, body mass index), implant (including design, manufacturer, sizes) and surgical factors (including American Society of Anesthesiology grade[16], approach, indication and surgeon grade) for each replacement procedure. The NJR has high levels of patient consent and link ability to subsequent surgery[4].

Anonymized patient data for all primary Oxford UKRs from January 1, 2005 to December 31, 2016 (n=50,334) were obtained from the NJR database. After data cleaning, 40,522 UKRs (30,814 cemented and 9,708 cementless) were eligible for inclusion (Figure 1).

We undertook two analyses. Firstly with the cleaned unmatched data we determined the number of cemented and cementless UKR implanted each year and calculated the implant survival. This is the analysis the NJR would perform if they subdivided the Oxford UKR into cemented and cementless and ignores confounding factors. Secondly we matched the fixation groups to allow fair comparison. In both the matched and unmatched groups we explored the relationship between caseload and revision rate.

The exposure of interest was surgeon caseload, defined as the mean number of UKRs performed per annum. Every surgeon in the NJR has a specific identifier which was used to calculate each operating surgeon's UKR caseload for each calendar year. The mean caseload (cases per year) was then calculated for each surgeon, but excluding years in which surgeons were inactive to prevent artificial reductions for surgeons who started operating in later years or those who subsequently stopped performing UKRs[7]. Each patient was allocated a value representing the caseload of the operating surgeon. Surgeon caseloads were grouped into low (<10 cases/yr), medium (10 to <30 cases/yr) and high volume (≥ 30 cases/yr). These thresholds have previously been described by Liddle, et al[7] and are evidence based unlike other thresholds[17]. Liddle, et al[7] found, that revision rates fell steeply with increasing caseload up 10 cases/yr. Thereafter they decreased at a slower rate until they plateaued at ≥30 cases/yr.

Given the potential for other known patient[18-21], surgical[7, 22-26] and implant factors[27, 28] to affect the revision rate we matched the cemented and cementless groups for multiple confounders using propensity scores. Logistic regression generated a propensity score representing the probability of receiving a cementless replacement. These scores were generated from patient, surgical and implant factors. The specific variables used for matching are summarized in Table 1, except body mass index (BMI) which had a large proportion of missing data, consistent with previous studies[29, 30].

We matched on the propensity score's logit with a 0.02-SD calliper width with a one to one matching ratio. Greedy matching without replacement was utilised given its superior performance for estimating treatment effects[31]. A comparison of standardized mean differences (SMDs) before and after matching were used to assess for covariate imbalances between fixation groups. SMDs ≥10% are suggestive of covariate imbalance[31]. 14,814 UKRs (7,407 cemented and 7,407 cementless) were included in the matched analysis.

<u>Statistical analysis</u>

The study outcome of interest was implant survival. The endpoint for implant survival was all cause revision surgery (any component inserted, exchanged or removed since primary surgery) for all indications. Cumulative implant survival was calculated using Kaplan-Meier analysis. Cumulative implant survival rates were compared between fixation groups across different caseload groups, using Cox regression models. To account for patient clustering within surgeons a multi-level frailty model was used. For clustering within the matched cohort a robust variance estimator was utilised. Adjusted models included covariates with residual imbalance after matching (defined as an SMD ≥10%). The revisions per 100 component years are also reported with 95% confidence intervals (CIs) using the Clopper Pearson exact method[32]. All analyses were performed using Stata (Version 15.1; Lakeway Drive TX).

SOURCE OF FUNDING

The funding source did not play a role in investigation.

RESULTS

Unmatched analysis

The unmatched cohort included 40,522 UKRs (30,814 cemented, 9,708 cementless UKRs). The number of cementless implanted each year has been increasing with 2832 cementless and 1717 cemented implanted in 2016 (Table 1). The mean patient's age **at the time of implantation** was 64.7 years (SD 9.5), with 21,747 males (53.7%). The mean BMI was 30.2 kg/m^2 (SD 5.0) and osteoarthritis was the surgical indication in 40,059 knees (98.9%).

The mean follow up for cemented and cementless implants in the unmatched cohort were 6.4 years (SD 3.1) and 3.5 years (SD 2.1), respectively. In total 2647 knees (258 cementless, 2389 cemented) underwent revision surgery. 10-year implant survival rates for unmatched cementless and cemented UKRs were 93.3% (CI=89.8–95.7) and 89.1% (CI=88.6-89.6), respectively (Figure 2). Cementless UKRs had significantly better implant survival (hazard ratio (HR)=0.59, CI=0.52-0.68);p<0.001). However, the baseline characteristics for unmatched cemented and cementless implants differed significantly (Table 1). The proportion of low volume surgeons was significantly (p<0.001) greater for cemented (43.7%) than cementless (27.4%), whereas the proportion of high volume surgeons was significantly greater (p<0.001) for cementless than cemented UKR (30.4% compared to 15.1%).

Analysis of the effect of caseload on the whole unmatched cohort showed 10-year implant survival of 86.6% (CI=85.8-87.3), 90.8% (CI=90.1-91.5) and 94.1% (CI=93.2-94.8) in low, medium and high volume surgeons (Figure 3). The revision rates for medium and high volume surgeons were significantly lower than low volume surgeons. The HR's were 0.67

(CI=0.62-0.73, p<0.001) and 0.42 (CI=0.37-0.48, p<0.001) respectively. The number of surgeons who were categorized as low, medium and high volume were 1275, 147 and 19, respectively.

Matched analysis

The matched cohort consisted of 14,814 UKRs (7407 cemented, 7407 cementless UKRs). The mean age was 64.7 years (SD 9.5), with 8659 males (58.4%). Mean BMI was 30.3 kg/m^2 (SD 5.0) and osteoarthritis was the surgical indication in 14,633 knees (98.8%).

Patient, surgical and implant factors were balanced between fixation groups after propensity matching (Table 1). The only variable with residual imbalance was year of surgery, which did not alter the results when adjusted for in the regression models. The mean follow up for both cemented and cementless UKRs were 4 years (SD 2.0). Although BMI was not used in the matching process, it was adequately balanced both before and after matching (Table 1).

In total 507 knees (218 cementless, 289 cemented) had revision surgery. Ten-year implant survival rates were 93.2% (CI=89.7-95.6) and 90.2% (CI=87.5-92.3) for cementless and cemented UKRs, respectively (Figure 4). Cementless UKRs had a significantly lower revision rate (HR=0.76, CI=0.64-0.91,p=0.002).

In the matched cohort the 10-year implant survival for the cementless and cemented groups respectively for low volume surgeons were; 86.8% (CI=73.6-93.7) and 81.8% (CI=73.0–88.0); for medium volume surgeons were 94.3% (CI=92.2-95.9) and 92.5 (CI=89.9-94.5);

and for high volume surgeons were 97.5% (CI=96.5-98.2) and 94.2% (CI=90.8-96.4). The 10-year cumulative revision rates are presented in Figure 5.

For all caseloads cementless UKRs had a lower revision rate than cemented UKRs. It was 26% lower in low volume surgeons (HR=0.74,CI=0.56-0.98,p=0.03), 21% lower in medium volume surgeons (HR=0.79,CI=0.60–1.02,p=0.08) and 20% lower in high volume surgeons (HR=0.80,CI=0.52–1.24,p=0.32). There was no significant interaction between fixation and caseload (p=0.92).

The revisions per 100 component years for the cementless and cemented groups respectively were; for low volume surgeons 1.12 (CI=0.89-1.37) and 1.49 (CI=1.24-1.78); for medium volume surgeons 0.73 (CI=0.59-0.89) and 0.93 (CI=0.77-1.11); and for high volume surgeons 0.45 (CI=0.31-0.62) and 0.57 (CI=0.42-0.76). In the matched cohort the number of surgeons who were categorized as low, medium and high volume were 729, 140 and 19, respectively.

DISCUSSION

Our NJR data analysis shows the use of the cementless Oxford has been rapidly increasing, with twice as many cementless implanted as cemented in 2016. Despite the cementless Oxford UKR now being the most commonly used UKR the NJR has not published its results. In our unmatched analysis the 10-year survival of the cementless Oxford UKR was 93.3%, with the revision rate being 41% less than that of the cemented version. These results were virtually the same as those in the NZJR, which reports a 10 yr survival for the cementless of 93%[6]**.** The cementless 10-year survival was better than or similar to that of all other UKRs reported in the NJR[4]. However, such comparisons are of little value as other surgeon or patient related factors are likely to have a greater influence on revision rate than the implant itself. Therefore, when making comparisons between implants it is important not only to match for confounding variables but also to consider their effects.

Having matched for confounding variables the revision rate for the cementless was, as previously demonstrated, 24% less than the cemented[15]. Therefore, the remaining difference from 24% to 41% is likely explained by other variables such as caseload. We found that increasing caseload was associated with a marked decrease in revision rate and that more high volume surgeons and fewer low volume surgeons were using cementless implants rather than the cemented, confirming caseload is an influential variable. Importantly there was no interaction between caseload and fixation, with cementless fixation associated with a decreasing revision rate by about a quarter for low, medium and high volume surgeons. We believe this is the first time that a cementless knee replacement has been demonstrated to have lower revision rates than its cemented counterpart for both experienced and inexperienced surgeons.

Although cementless fixation is considered to be more durable in the long term than cemented, it is generally accepted that it is less forgiving[33]. In particular bone resections must be performed accurately, avoiding any gaps between the host bone and the components to ensure primary stability. It is therefore surprising that we found low volume UKR surgeons, who tend to be less experienced, have better results with cementless fixation than cemented. Furthermore, in the Oxford UKR, loads are mainly compressive with minimal shear, owing to ligament preservation and the mobile unconstrained bearing. This is advantageous for cementless fixation. Therefore, the results of this study may not apply to other types of UKR or TKR.

We found with both cemented and cementless UKRs the revision rate decreased with increasing surgeon volume. Although this probably relates to surgical technique it may also relate to the indications for UKR. The primary indications are anteromedial osteoarthritis with bone-on-bone arthritis medially, full thickness cartilage present laterally, and functionally normal ligaments[34]. These criteria are assessed radiographically and confirmed intraoperatively[34] but are not collected by the NJR which only reports the primary indication for surgery. Therefore from NJR data it is not possible to determine the precise indications for surgery. However studies suggest the indications are satisfied in up to 50% of knee replacements[35]. An insight into the indications can be determined from the usage of UKR, which is defined as the proportion of primary knee replacements that are UKR compared to TKR. Previous work has shown that surgeons with high usage (≥30%) tend to use the correct indications and achieve better results, whereas surgeons with low usage (<10%) often use UKR for early arthritis and get worse results[36].

Low volume UKR surgeons, had high 10-year revision rates whether they used cementless or cemented UKR. We believe that these surgeons should considering focus on their UKR practice rather than the type of implant fixation. Given they had high revision rates they should consider either stopping doing UKR or see if, by adhering to the recommended indications, they might increase their caseload to more than 10 cases/year[3, 35, 37]. From 80% to 90% of surgeons who have implanted UKR were considered low volume. However the majority of these surgeons had a large enough knee replacement practice to likely be able to do more than 10 UKR per year if they adhered to the recommended indications[7, 35]. Therefore, potentially many more UKR could be implanted which hopefully would lead to improvement in the overall results. Medium and high volume UKR surgeons using cemented components should consider changing to cementless fixaton as it may improve their outcomes. High volume surgeons using cementless components were found to achieve very good results with a 10-year implant survival of 97.5% which is similar as that achieved by the best TKR[4].

The main limitation is that our work is based on Registry data, which reports revision and not other outcomes. Registries can underreport revisions although this should not differ between groups[38, 39]. Furthermore, propensity matching has limitations of potential residual confounding and can reduce the result's generalizability. Fixation groups were not perfectly matched on the year of surgery, given cementless components were introduced after cemented. Although surgical practices typically improve with time, our results did not change when we adjusted year of surgery in the regression models. A substantial proportion of patients had missing BMI data, preventing us from matching on this variable. However, BMI was balanced between groups both before and after propensity matching. The only way to achieve perfect matching is with a randomized trial. However, to compare revision rates across different surgeon caseloads would be virtually impossible as it would require a very large sample size and many surgeons with a range of different caseloads. Therefore propensity matching is the best way of performing this study.

In conclusion, surgeon caseload had a profound effect on implant survival in both cemented and cementless knee UKRs with low caseload being associated with higher revision rates for both implant types. Surgeon caseload, however did not affect the relative performance of cemented and cementless replacements; the revision rate of the cementless replacements were about a quarter less than cemented across low, medium and high surgeon caseloads suggesting superior implant performance. Low volume UKR surgeons had high revision rates and we suggest that they should consider either stopping or doing more UKR. Medium and high volume surgeons, using cemented Oxford UKR components should consider changing to cementless fixation. High volume surgeons using cementless UKR achieved particularly good results with a 10-year survival of 97.5%.

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Figure 1. Data flowchart of NJR database cleaning

Figure 2. Kaplan Meier graph of the comparison of unmatched cemented and cementless knee replacements

Figure 3. Kaplan Meier graph of the effect of surgeon caseload on implant survival of the entire unmatched cohort.

Figure 4. Kaplan Meier graph of the comparison of matched cemented and cementless knee replacements

Figure 5. Bar chart of 10 year cumulative revision rate of matched cemented and cementless Oxford UKRs across different surgeon caseloads.

Table 1. Patient, implant and surgical factors before and after matching. Abbreviations: SD (Standard deviation), SMD (Standardised mean difference), VTE (Venous thromboembolism).

	Unmatched cohort (n=40,522)			**Matched cohort (n=14,814)**		
	Cemented UKR (n=30,814)	**Cementless UKR (n=9,708)**	**SMD**	**Cemented UKR (n=7407)**	**Cementless UKR (n=7407)**	**SMD**
Factor						
Sex						
Female	14,707 (47.7%)	4,068 (41.9%)	0.12	3077 (41.5%)	3078 (41.6%)	<0.001
Male	16,107 (52.3%)	5,640 (58.1%)		4330 (58.5%)	4329 (58.4%)	
Age (yr)						
Mean (SD)	64.7 (SD 9.5)	64.8 (SD 9.5)	0.01	64.6 (SD 9.6)	64.7 (SD 9.5)	0.003
Body mass index (kg/m^2)						
Mean (SD)	30.2 (SD 5, n=18,669)	30.4 (SD 5.2, n=8,297)	0.04	30.2 (SD 4.9, n=5565)	30.4 (SD 5.2, n=6236)	0.05
Diagnosis						
Primary osteoarthritis	30,474 (98.9%)	9,585 (98.7%)	0.02	7,314 (98.7%)	7,319 (98.8%)	0.006
Other	340 (1.1%)	123 (1.3%)		93 (1.3%)	88 (1.2%)	
Bilateral UKRs	874 (2.8%)	451 (4.6%)	0.1	245 (3.3%)	248 (3.4%)	0.002
ASA grade						
1	6321 (20.5%)	2120 (21.8%)	0.05	1,536 (20.7%)	1,489 (20.1%)	0.02
2	21,983 (71.3%)	6704 (69.1%)		5,227 (70.6%)	5,272 (71.2%)	
3 or over	2510 (8.1%)	884 (9.1%)		644 (8.7%)	646 (8.7%)	

VTE –chemical						
LMWH (+/-other)	17,561 (57.0%)	6,228 (64.2%)	0.40	4,624 (62.4%)	4,687 (63.3%)	0.02
Aspirin only	4,152 (13.5%)	1006 (10.4%)		727 (9.8%)	719 (9.7%)	
Other	5,496 (17.8%)	2,251 (23.2%)		1,851 (25.0%)	1,790 (24.2%)	
None	3,605 (11.7%)	223 (2.3%)		205 (2.8%)	211 (2.8%)	
VTE – mechanical						
Any	29,316 (95.1%)	9,631 (99.2%)	0.25	7,332 (99.0%)	7,330 (99.0%)	0.003
None	1,498 (4.9%)	77 (0.8%)		75 (1.0%)	77 (1.0%)	
Operative year						
2005	1100 (3.6%)	8 (0.1%)	1.32	9 (0.1%)	8 (0.1%)	0.18
2006	1889 (6.1%)	40 (0.4%)		38 (0.5%)	40 (0.5%)	
2007	2702 (8.8%)	28 (0.3%)		61 (0.8%)	28 (0.4%)	
2008	3344 (10.9%)	82 (0.8%)		147 (2.0%)	82 (1.1%)	
2009	3460 (11.2%)	261 (2.7%)		238 (3.2%)	261 (3.5%)	
2010	3256 (10.6%)	404 (4.2%)		349 (4.7%)	403 (5.4%)	
2011	3013 (9.8%)	639 (6.6%)		417 (5.6%)	637 (8.6%)	
2012	2962 (9.6%)	718 (7.4%)		695 (9.4%)	705 (9.5%)	
2013	2622 (8.5%)	960 (9.9%)		996 (13.4%)	864 (11.7%)	
2014	2637 (8.6%)	1545 (15.9%)		1500 (20.3%)	1,262 (17.0%)	
2015	2112 (6.9%)	2191 (22.6%)		1528 (20.6%)	1,555 (21.0%)	
2016	1717 (5.6%)	2832 (29.2%)		1429 (19.3%)	1,562 (21.1%)	

Surgeon grade						
Consultant	27,775 (90.1%)	8,571 (88.3%)	0.06	6,688 (90.3%)	6,622 (89.4%)	0.03
Other	3,039 (9.9%)	1,137 (11.7%)		719 (9.7%)	785 (10.6%)	
Surgeon caseload						
<10 cases/year	13,474 (43.7%)	2,656 (27.4%)	0.43	2327 (31.4%)	2364 (31.9%)	0.01
10 to <30 cases/year	12,685 (41.2%)	4,100 (42.2%)		3336 (45.0%)	3328 (44.9%)	
≥30 cases/year	4,655 (15.1%)	2,952 (30.4%)		1744 (23.5%)	1715 (23.2%)	
Surgical approach						
Medial parapatellar	28,154 (91.4%)	8,898 (91.7%)	0.01	6,827 (92.2%)	6,822 (92.1%)	0.003
Other	2,660 (8.6%)	810 (8.3%)		580 (7.8%)	585 (7.9%)	
Minimally invasive surgery						
0	16,287 (52.9%)	4,789 (49.3%)	0.07	3,796 (51.3%)	3,804 (51.4%)	0.002
1	14,527 (47.1%)	4,919 (50.7%)		3,611 (48.8%)	3,603 (48.6%)	
Size of femoral component						
Ex small	47 (0.2%)	42 (0.4%)	0.14	26 (0.4%)	21 (0.3%)	0.02
Small	6904 (22.4%)	2504 (25.8%)		1,752 (23.7%)	1,727 (23.3%)	
Medium	16,608 (53.9%)	4,606 (47.4%)		3,617 (48.8%)	3,663 (49.5%)	
Large	7,171 (23.3%)	2,529 (26.1%)		1,990 (26.9%)	1,980 (26.7%)	
Ex-Large	84 (0.3%)	27 (0.3%)		22 (0.3%)	16 (0.2%)	

Size of tibial component						
AA	93 (0.3%)	37 (0.4%)	0.37	29 (0.4%)	29 (0.4%)	0.01
A	3453 (11.2%)	352 (3.6%)		336 (4.5%)	343 (4.6%)	
B	7288 (23.7%)	1870 (19.3%)		1,513 (20.4%)	1,481 (20.0%)	
C	8769 (28.5%)	2807 (28.9%)		2,137 (28.9%)	2,147 (29.0%)	
D	7098 (23.0%)	2570 (26.5%)		1,974 (26.7%)	1,991 (26.9%)	
E	3216 (10.4%)	1537 (15.8%)		1095 (14.8%)	1084 (14.6%)	
F	897 (2.9%)	535 (5.5%)		323 (4.4%)	332 (4.5%)	
Type of bearing						
Anatomic	23,301 (75.6)	9,407 (96.9%)	0.65	7,092 (95.8%)	7,106 (95.9%)	0.009
Symmetric	7,513 (24.4%)	301 (3.1%)		315 (4.3%)	301 (4.1%)	
Size of bearing						
3	6226 (20.3%)	3003 (30.9%)	0.37	2056 (27.8%)	2000 (27.0%)	0.02
4	12,126 (39.4%)	4093 (42.2%)		3128 (42.2%)	3160 (42.7%)	
5	6765 (22.0%)	1787 (18.4%)		1459 (19.7%)	1483 (20.0%)	
6	3268 (10.6%)	578 (6.0%)		519 (7.0%)	523 (7.1%)	
7	1506 (4.9%)	161 (1.7%)		150 (2.0%)	156 (2.1%)	
8	563 (1.8%)	57 (0.6%)		62 (0.8%)	56 (0.8%)	
9	320 (1.0%)	29 (0.3%)		33 (0.4%)	29 (0.4%)	

Bone graft						
None	30,745 (99.8%)	9,629 (99.2%)	0.08	7,377 (99.6%)	7,381 (99.7%)	0.009
Bone graft used	69 (0.2%)	79 (0.8%)		30 (0.4%)	26 (0.4%)	

Figure 1

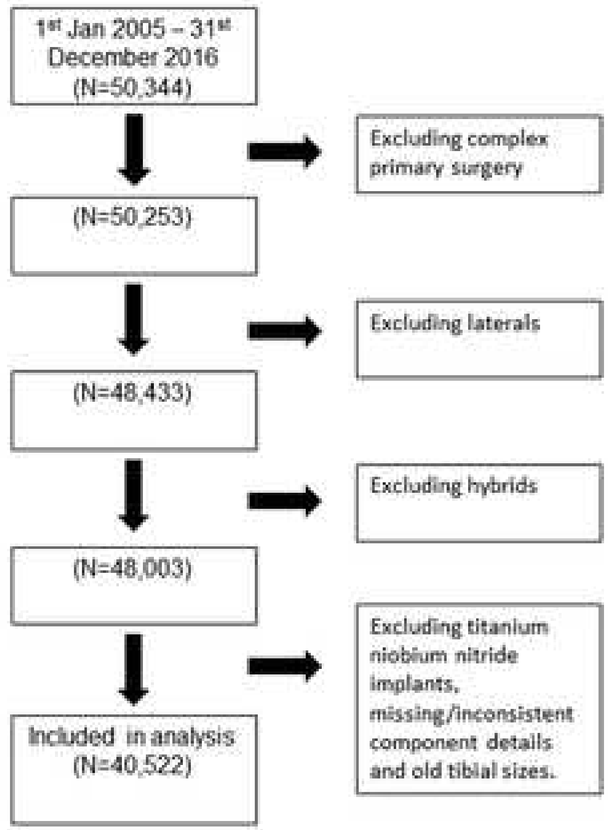

1st Jan 2005 – 31st December 2016 (N=50,344)
Excluding complex primary surgery
(N=50,253)
Excluding laterals
(N=48,433)
Excluding hybrids
(N=48,003)
Excluding titanium niobium nitride implants, missing/inconsistent component details and old tibial sizes.
Included in analysis (N=40,522)

Figure 2

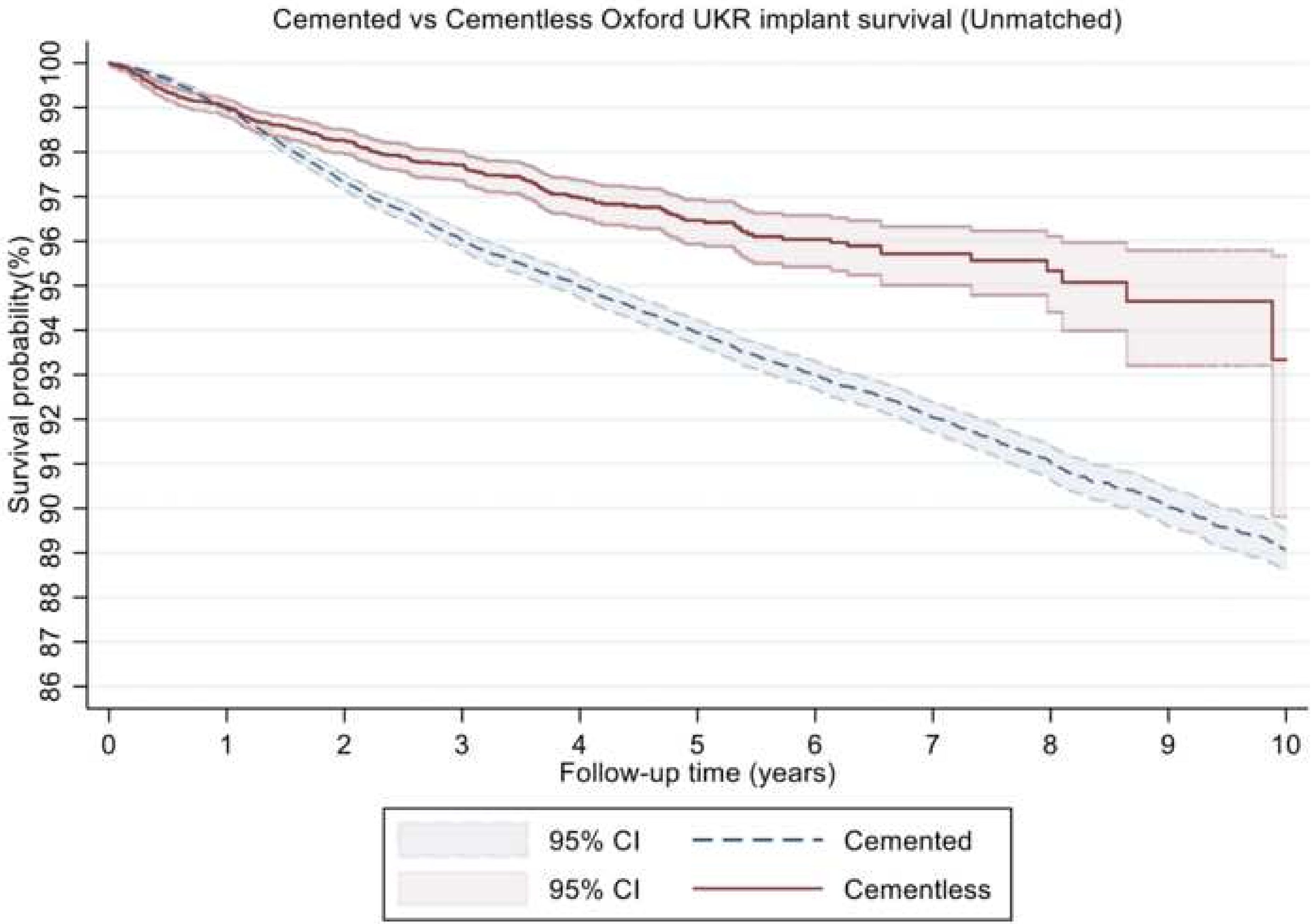

Cemented vs Cementless Oxford UKR implant survival (Unmatched)
Survival probability(%)
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
0
1
2
3
4
5
6
7
8
9
10
Follow-up time (years)
95% CI
Cemented
95% CI
Cementless

Figure 3

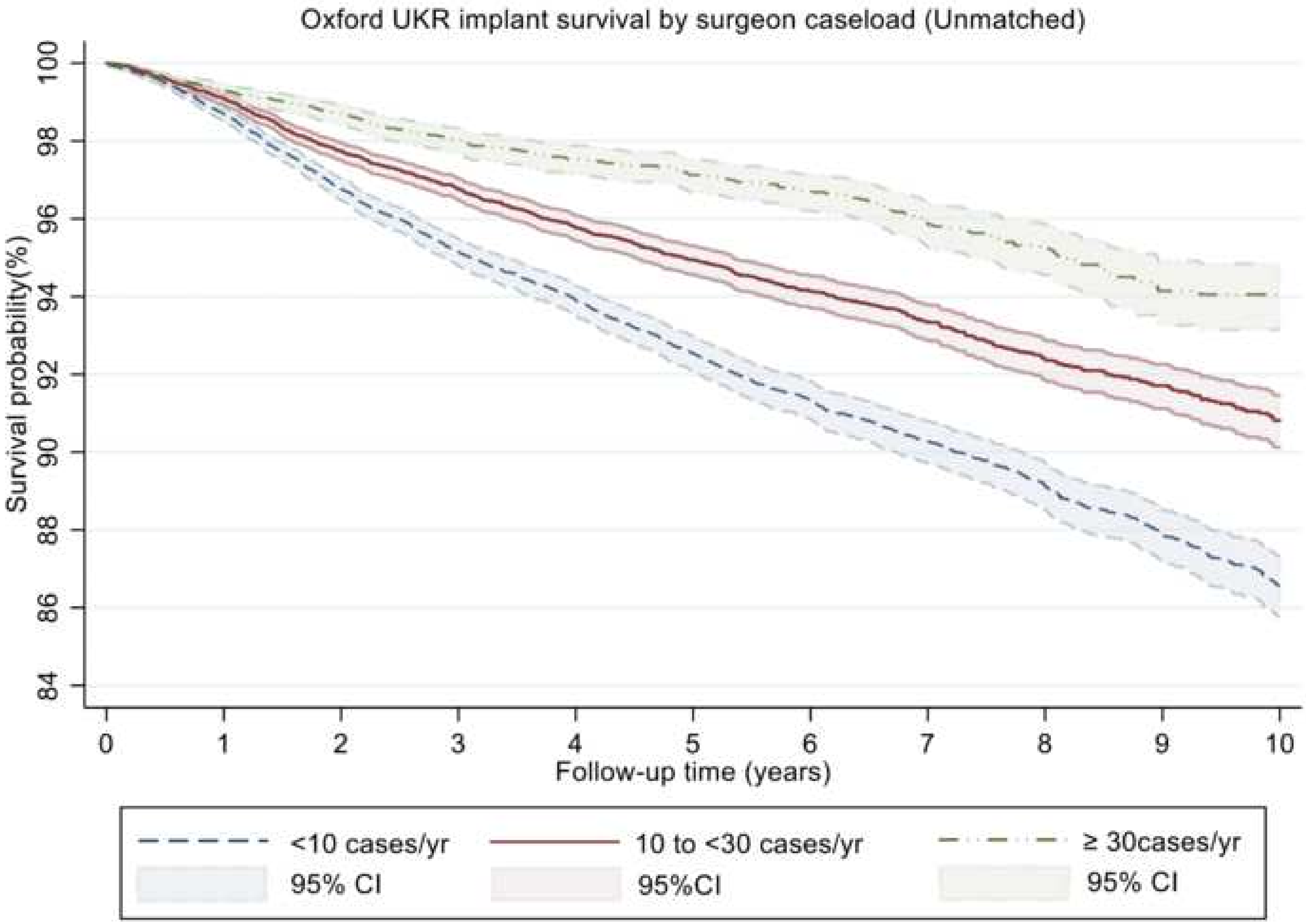

Oxford UKR implant survival by surgeon caseload (Unmatched)
Survival probability(%)
100
98
96
94
92
90
88
86
84
0
1
2
3
4
5
6
7
8
9
10
Follow-up time (years)
<10 cases/yr
95% CI
10 to <30 cases/yr
95%CI
≥ 30cases/yr
95% CI

Figure 4

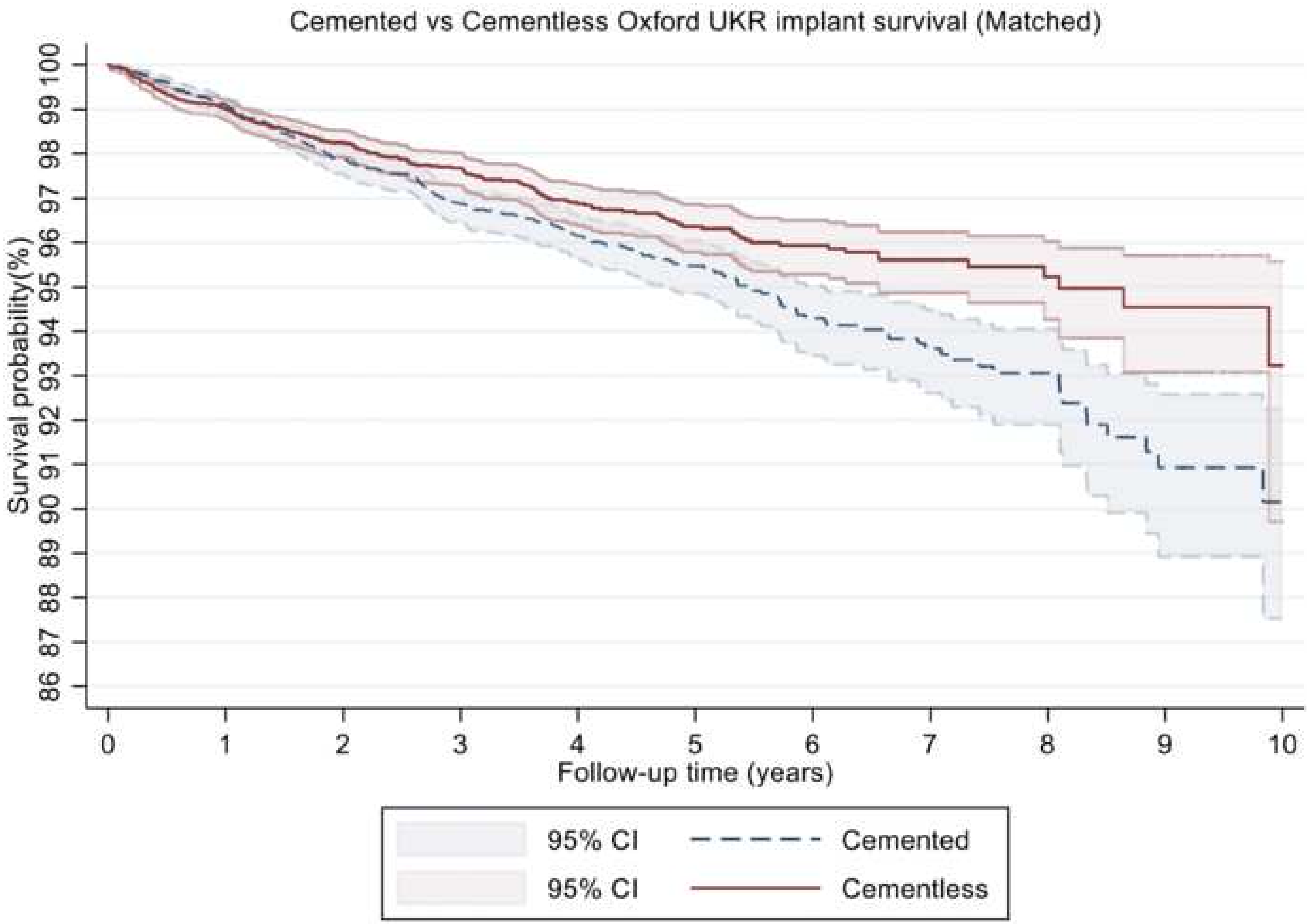
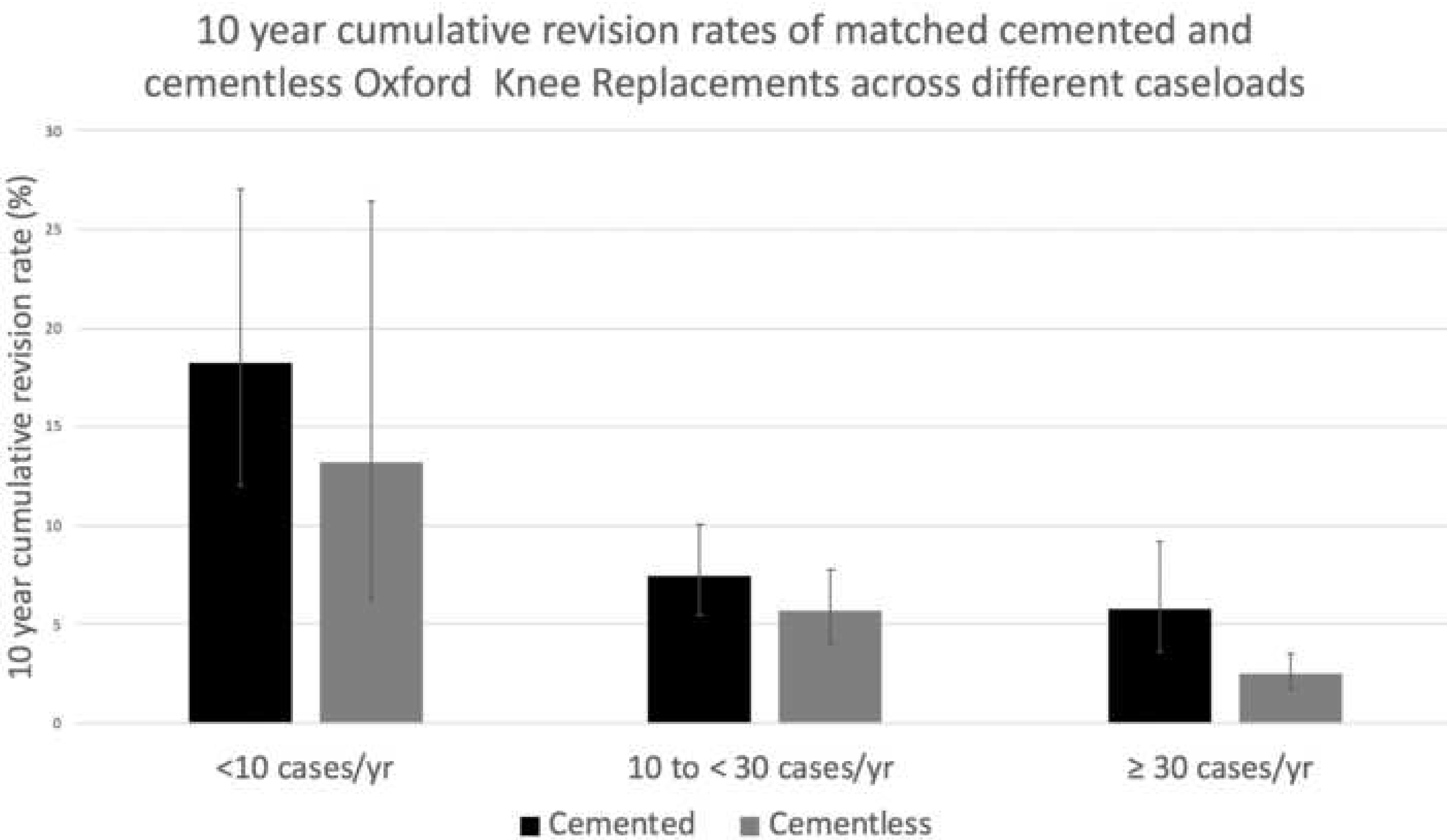

Cemented vs Cementless Oxford UKR implant survival (Matched)
Survival probability(%)
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
0
1
2
3
4
5
6
7
8
9
10
Follow-up time (years)
95% CI
Cemented
95% CI
Cementless

Figure 5


10 year cumulative revision rates of matched cemented and cementless Oxford Knee Replacements across different caseloads
10 year cumulative revision rate (%)
30
25
20
15
10
5
0
<10 cases/yr
10 to < 30 cases/yr
≥ 30 cases/yr
Cemented
Cementless

CME Questions Submission Form

Enter all questions on this form. A total of 3 multiple-choice questions are required. Please review the *Guidelines for Creation of CME Questions* in the Author Resource Center section of the JBJS website before submitting your questions.

Manuscript number: JBJS-D-19-01060
Article title: The effect if surgeon caseload on the relative revision rate of cemented and cementless Unicompartmental Knee Replacements: An analysis from the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man.

Question 1

I. Does this question have an associated image or images?

☐ Yes ☒ No

(If YES – upload image(s) separately using the "CME Question Figure" item option in the Attach Files screen of Editorial Manager. Include a one to two sentence description of each figure here. All figures should be at least 5x7 inches with a resolution of 300 ppi.)

II. Question: (A patient-care scenario is preferred when appropriate; see *Guidelines* link above)

Does fixation affect the revision rate of mobile bearing Unicompartmental Knee Replacements (UKR)?

III. Options: *(In alphabetical or logical order.* ***Please do not use "all of the above" or "none of the above" as potential answer choices.****)*

A.	Cementless UKRs perform significantly better.
B.	Cementless UKRs perform slightly better.
C.	No difference between Cemented and Cementless UKRs.
D.	Cemented UKRs perform slightly better.
E.	Cemented UKRs perform significantly better.

IV. Answer: (must be *clearly* the best of the options)

☒ A. ☐ B. ☐ C. ☐ D. ☐ E.

V. Correct Answer Location: Please identify the manuscript section where the correct answer is located (e.g. "Results" or "Discussion")

Results

VI. Supporting Statement: Please include one sentence from the section identified above supporting the correct answer.

Cementless UKRs had a significantly reduced revision rate compared with cemented UKRs (HR=0.76,CI 0.64-0.91,p=0.002).

Question 2

V. Does this question have an associated image or images?

☐ Yes ☒ No

(If YES – upload image(s) separately using the "CME Question Figure" item option in the Attach Files screen of Editorial Manager. Include a one to two sentence description of each figure here. All figures should be at least 5x7 inches with a resolution of 300 ppi.)

VI. Question: (A patient-care scenario is preferred when appropriate; see *Guidelines* link above)

How do the results of mobile bearing Cementless UKRs compare to Cemented UKRs with different surgeon caseloads?

VII. Options: *(In alphabetical or logical order. **Please do not use "all of the above" or "none of the above" as potential answer choices.**)*

A.	Cementless UKR performs significantly better across all caseloads.
B.	Cementless UKR is only better for high volume surgeons.
C.	No difference in all caseloads.
D.	Cemented UKR performs better for low volume surgeons.
E.	Cemented UKR performs significantly better across all caseloads.

VIII. Answer: (must be *clearly* the best of the options)

☒ A. ☐ B. ☐ C. ☐ D. ☐ E.

V. Correct Answer Location: Please identify the manuscript section where the correct answer is located (e.g. "Results" or "Discussion")

Results

VI. Supporting Statement: Please include one sentence from the section identified above supporting the correct answer.

For all caseloads cementless UKRs had a lower revision rate than cemented UKRs. It was 26% reduced in low volume surgeons, 21% reduced in medium volume surgeons and 20% reduced in high volume surgeons.

Question 3

IX. Does this question have an associated image or images?

☐ Yes ☒ No

(If YES – upload image(s) separately using the "CME Question Figure" item option in the Attach Files screen of Editorial Manager. Include a one to two sentence description of each figure here. All figures should be at least 5x7 inches with a resolution of 300 ppi.)

X. Question: (A patient-care scenario is preferred when appropriate; see *Guidelines* link above)

How do Unicompartmental Knee Replacements revision rates compare to those in Total Knee Replacements?

XI. Options: *(In alphabetical or logical order.* ***Please do not use "all of the above" or "none of the above" as potential answer choices.****)*

A.	Lower UKR revision rates for high caseload surgeons.
B.	Lower UKR revision rates for all surgeons irrespective of caseload.
C.	Higher UKR revision rates for all surgeons irrespective of caseload.
D.	Similar for high caseload surgeons.
E.	Similar for all surgeons irrespective of caseload.

XII. Answer: (must be *clearly* the best of the options)

☐ A. ☐ B. ☐ C. ☒ D. ☐ E.

V. Correct Answer Location: Please identify the manuscript section where the correct answer is located (e.g. "Results" or "Discussion")

Results

VI. Supporting Statement: Please include one sentence from the section identified above supporting the correct answer.

In the matched cohorts the 10-year implant survival for the cementless and cemented groups respectively for low volume surgeons were; 86.8% (CI 73.6-93.7) and 81.8% (CI 73.0–88.0); for medium volume surgeons were 94.3% (CI 92.2-95.9) and 92.5 (CI 89.9-94.5); and for high volume surgeons were 97.5% (CI 96.5-98.2) and 94.2% (CI 90.8-96.4).