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RESEARCH ARTICLE

One-year Oxford knee scores should be used in preference to 6-month scores when assessing the outcome of total knee arthroplasty

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Abstract

Purpose: The primary aim of this study was to assess whether there was a clinically significant difference in the mean Oxford knee score (OKS) between 6 and 12 months after total knee arthroplasty (TKA). The secondary aim was to identify variables associated with a clinically significant change in the OKS between 6 and 12 months.

Methods: A retrospective cohort study was undertaken using an established arthroplasty database of 1574 primary TKA procedures. Patient demographics, body mass index (BMI), comorbidities, OKS and EuroQoL 5-domain (EQ-5D) score were collected preoperatively and at 6 and 12 months postoperatively. A clinically significant change in the OKS was defined as 5 points or more.

Results: There was a 1.1-point increase in the OKS between 6 and 12 months postoperatively, which was statistically significant (95% confidence (CI) 0.8–1.3, $p < 0.0001$). There were 381 (24.2%) patients who had a clinically significant improvement in their OKS from 6 to 12 months. After adjusting for confounding, patients with a lower BMI ($p = 0.028$), without diabetes mellitus ($p < 0.001$), a better preoperative OKS ($p < 0.001$) or a worse 6-month OKS ($p < 0.001$) were more likely to have a clinically significant improvement. A 6-month OKS < 36 points was a reliable predictor of a clinically significant improvement in the 6-month to 12-month OKS (area under the curve 0.73, 95% CI 0.70–0.75, $p < 0.001$).

Conclusion: Overall, there was no clinically significant change in the OKS from 6 to 12 months; however, a clinically significant improvement was observed in approximately a quarter of patients and was more likely in those scoring less than 36 points at 6 months. Level of evidence: retrospective diagnostic study, level III.

Keywords: Change, Difference, 6 Months, 12 Months, Total knee arthroplasty, Outcome, Oxford knee score

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Clement *et al. Knee Surgery & Related Research*   (2020) 32:43

Page 2 of 8

Introduction

Patient reported outcome measures (PROMs) are valuable tools that are commonly used to assess the outcome of total knee arthroplasty (TKA) [1]. The Oxford knee score (OKS) [2] is a joint-specific PROM and is the outcome measure of choice in England and Wales to evaluate the functional outcome of TKA [3]. The OKS is a validated assessment tool and has been shown to be reliable, reproducible and capable of measuring a clinical change after TKA [2, 4]. A greater improvement in the OKS has been demonstrated to correlate with an increased rate of patient satisfaction with the outcome of their TKA [5, 6].

The optimal timepoint at which the OKS should be assessed after TKA is not clear. A systematic review by Browne et al. [7] recommended that the 12-month OKS be used rather than the 6-month OKS as there was a further 2-point improvement from 6 to 12 months postoperatively. The OKS appears to peak at 12 months and remains stable into the mid to long term [8–10]. If the OKS increases further between 6 and 12 months, this may lead to differing conclusions when assessing the same cohort of patients [11, 12]. Although there may be a 2-point improvement in the OKS from 6 to 12 months after TKA, it is not known whether this is statistically and clinically significant or which patients are more likely to experience OKS improvement.

The primary aim of this study was to assess the whether there was a clinically significant difference in the mean OKS between 6 and 12 months after TKA. The secondary aims were to (1) identify predictors of change in the 6-month to 12-month OKS, (2) assess the proportion of patients that had a clinically significant change in their OKS between 6 and 12 months and (3) identify independent variables associated with a clinically significant change. The null hypothesis was that no clinically significant change occurs in the OKS between 6 and 12 months.

Patients and methods

Patients for this study were identified retrospectively from a prospectively compiled arthroplasty database held at the study centre. During a 57-month period (January 2013 to September 2017) 2550 TKA were performed at the study centre and patients were asked to complete a preoperative patient questionnaire at their preassessment clinic. Medical staff were on hand to assist and answer any questions. The patient demographics, body mass index (BMI) and comorbidities were recorded at the preoperative assessment. Categories of comorbidity included were myocardial infarction (MI), heart failure, peripheral vascular disease (PVD), stroke, dementia, chronic obstructive airways disease (COPD), diabetes mellitus, back pain and pain in other joints, which were

recorded as dichotomous variables. Patients who did not complete their OKS assessments preoperatively or at 6 and 12 months were also excluded from analysis. There were 976 (38.3%) patients excluded as they did not complete their preoperative OKS and their 6-month or 12-month OKS. The study cohort consisted of 1574 event-linked OKS. Patients excluded were slightly younger (70.3 versus 69.1 years, difference 1.2, 95% confidence intervals (CI) 0.5–1.9, $p = 0.002$), but there was no difference in gender ($p = 0.13$) or BMI ($p = 0.18$). Patients were subsequently contacted at 6 and 12 months by post to complete functional assessment questionnaires. Patients were able to contact the orthopaedic team should they have had any questions at these assessment times.

The OKS was recorded preoperatively and at 6 and 12 months postoperatively. The OKS is derived from 12 questions assessed on a Likert scale with values from 0 to 4; a summative score is then calculated where 48 is the best possible score (least symptomatic) and 0 is the worst possible score (most symptomatic) [2]. The minimal clinically important difference (MCID) for the OKS is 5 points, which is thought to represent a clinical difference between two groups of patients [10].

The EuroQoL (EQ) general health questionnaire, which evaluates five domains (5D) to assess mobility, self-care, usual activities, pain/discomfort and anxiety/depression, was recorded preoperatively and at 6 months postoperatively [13]. The 3-level (3-L) version of the EuroQoL questionnaire was used, with the responses to the five domains being recorded at 3 levels of severity (no problems; slight problems; moderate, severe or unable/extreme problems). This index is on a scale of – 0.594 to 1, where 1 represents perfect health, and less than 0 represents a state worse than death.

During the study period two type of implants were used: Triathlon (Stryker, Marwah, NJ, USA) and the PFC Sigma (DePuy, Johnson & Johnson Professional Inc., Raynham, MA, USA). A measured resection technique was used. All patients were reviewed at a preassessment clinic. A standardised rehabilitation protocol was used for all patients, with active mobilisation on the first postoperative day. Patients were then reviewed at 6 weeks, 6 months and 12 months postoperatively.

Statistical analysis was performed using the Statistical Package for Social Sciences version 17.0 (SPSS Inc., Chicago, IL, USA). Student's paired or unpaired t test was used to compare linear variables between groups. Dichotomous variables were assessed using the chi square test. Pearson's correlation was used to assess the relationship between linear variables. Multivariate linear regression analysis was used to identify independent predictors associated with change in the OKS from 6 to 12 months. Simple linear regression analysis was used to identify change in the 6–12-

month OKS according to the 6-month OKS. Multivariate logistic regression analysis was used to identify independent predictors associated with change greater than the MCID in the OKS from 6 to 12 months. Receiver operating characteristic (ROC) curve analysis was used to identify a threshold (cut points) in scalar variables (preoperative and 6 months OKS and BMI) that were independently associated with a change equal to or greater than the MCID between 6 and 12 months. The area under the curve (AUC) ranges from 0.5, indicating a test with no accuracy, to 1.0 where the test is perfectly accurate by identifying all satisfied patients. A p value <0.05 was defined as significant. A post hoc power calculation was performed using the OKS (primary outcome measure) and the MCID of 5 points [10] with standard deviation (SD) of 10 points and alpha of 0.05, and using a two-way analysis, power of 100% was achieved in this study cohort (n = 1574).

Ethical approval was obtained from the regional ethics committee (Research Ethics Committee, South East Scotland Research Ethics Service, Scotland (11/AL/007)]) for analysis and publication of the presented data.

Results

There were 1574 TKA performed during the study period with complete preoperative and postoperative data that met the inclusion criteria. There were 711 male patients and 863 female patients, with a mean age of 70.3 (SD 9.0, range 23–93) years. The mean preoperative OKS was 21.3 (SD 7.8), which by 6 months postoperatively had increased to a mean of 35.2 (SD 9.0); the 13.9-point improvement was significant (95% confidence interval (CI) 13.4–14.4, $p < 0.0001$ paired t test). At 12 months postoperatively the OKS increased further to 36.2 (SD 9.6) and the 15.0-point improvement was significant (95% CI 14.5–15.4, $p < 0.0001$ paired t test).

Primary outcome

There was a 1.1-point increase (improvement) in the OKS between 6 and 12 months postoperatively, which was statistically significant (95% CI 0.8–1.3, $p < 0.0001$ paired t test). However, this 1.1-point increase was not greater than the MCID.

Secondary outcomes

Predictors of change in OKS from 6 to 12 months

Patients without diabetes mellitus and patients with a better (greater) preoperative OKS, a worse 6-month OKS and a better EQ-5D at 6 months were significantly more likely to have a greater improvement in the OKS from 6 to 12 months on both unadjusted (Table 1) and multivariate (Table 2) analysis. None of the other co-morbidities, apart from diabetes mellitus, were associated with change in the OKS from 6 to 12 months

Table 1 Predictors of change in the OKS between 6 and 12 months after TKA

Demographic	Descriptive	Number	Mean (SD)	Difference/ correlation	95% CI	**P** value*
Gender	Male	711	1.1 (6.3)	Diff = 0.0	−0.6 to 0.6	0.98
	Female	863	1.1 (5.6)			
Age			–	$r = -0.04$		0.16**
BMI			–	$r = -0.05$		0.054**
Comorbidity	Not present			Reference***		
	MI	65	0.3 (7.4)	Diff = 0.8	−0.6 to 2.3	0.27
	Heart Failure	15	3.1 (9.6)	Diff = 2.0	−1.0 to 5.0	0.18
	PVD	31	1.1 (8.1)	Diff = 0.1	−2.0 to 2.2	0.93
	Stroke	10	−1.8 (8.1)	Diff = 3.0	−0.7 to 6.6	0.11
	COPD	57	0.8 (6.6)	Diff = 0.4	−1.2 to 1.9	0.66
	Diabetes	189	0.3 (6.6)	Diff = −1.0	−1.9 to −0.1	**0.04**
	Back pain	590	1.2 (6.4)	Diff = 0.2	−0.5 to 0.8	0.62
	Joint pain	1041	1.0 (5.9)	Diff = 0.4	−0.3 to 1.1	0.22
Functional measures						
OKS	Preoperative	1574	–	$r = 0.08$		**0.002****
	6 months	1574	–	$r = -0.23$		**< 0.001****
EQ 5D	Preoperative	1570	–	$r = 0.04$		0.14**
	6 months	1567	–	$r = -0.11$		**< 0.001****

TKA total knee arthroplasty, *OKS* Oxford Knee Score, *EQ 5D* EuroQoL 5-Dimension questionnaire, *BMI* body mass index; *MI* myocardial infarction, *PVD* peripheral vascular disease, *COPD* chronic obstructive pulmonary disorder, *CI* confidence interval, *Diff* difference
*Unpaired t test unless otherwise stated. **Pearson correlation. ***Difference relative to a patient without the stated comorbidity
Bold indicates statistical significance

Table 2 Independent predictors associated with change in the OKS from 6 to 12 months after TKA

Demographic	Descriptive	Change in OKS	95% CI	*P* value
BMI		−0.07	− 0.13 to − 0.02	0.011
Comorbidity	Not present	Reference		
	Diabetes mellitus	−1.2	−2.07 to −0.30	< 0.001
Functional measures				
OKS	Preoperative	0.14	0.10 to 0.18	< 0.001
	6 Months	−0.31	−0.37 to − 0.26	< 0.001
EQ 5D	6 Months	4.80	2.66 to 6.94	< 0.001

Linear regression analysis: all significant ($p < 0.05$) variables or variables with a trend towards statistical significance ($p < 0.1$) were entered into the model. The R^2 value of the model was 0.12
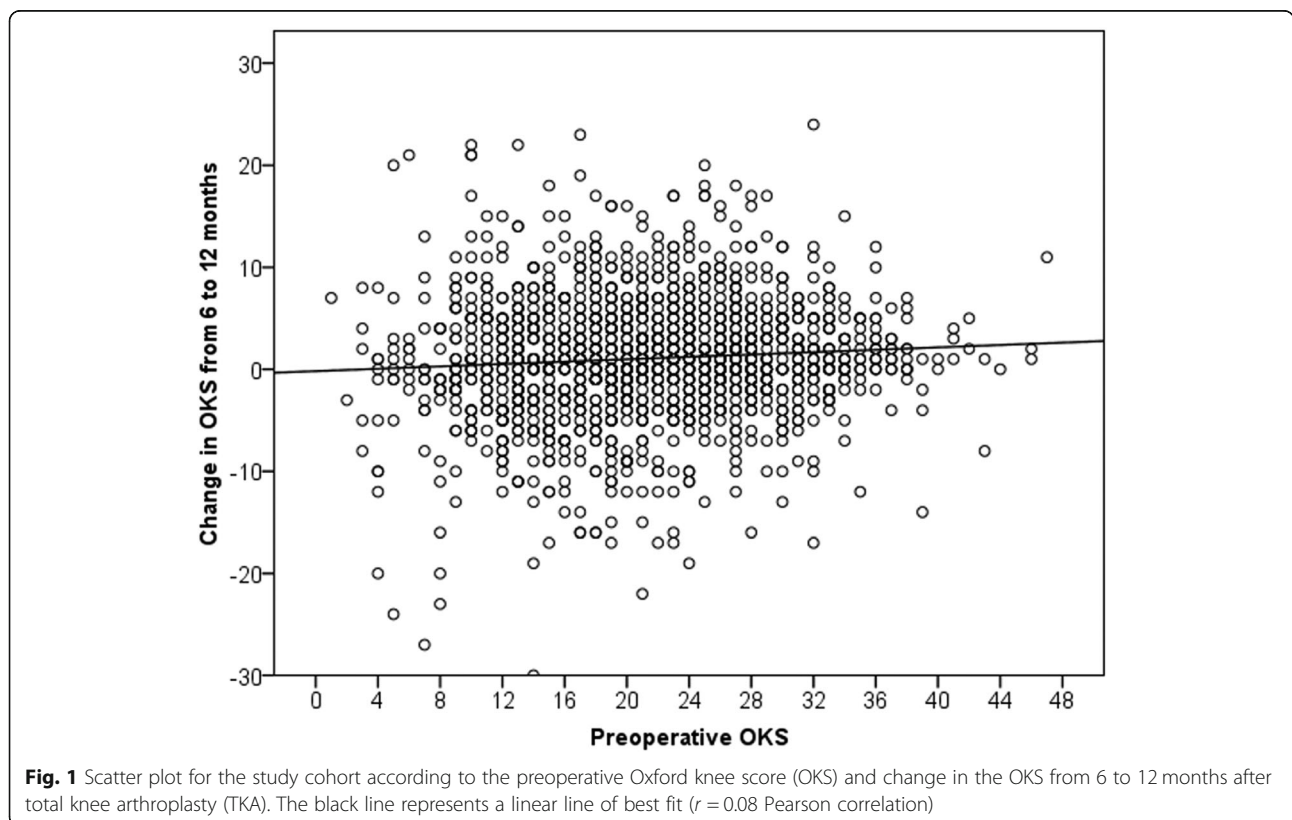
TKA total knee arthroplasty, *OKS* Oxford Knee Score; *EQ 5D* EuroQoL 5-Dimension questionnaire, *BMI* body mass index, *CI* confidence interval
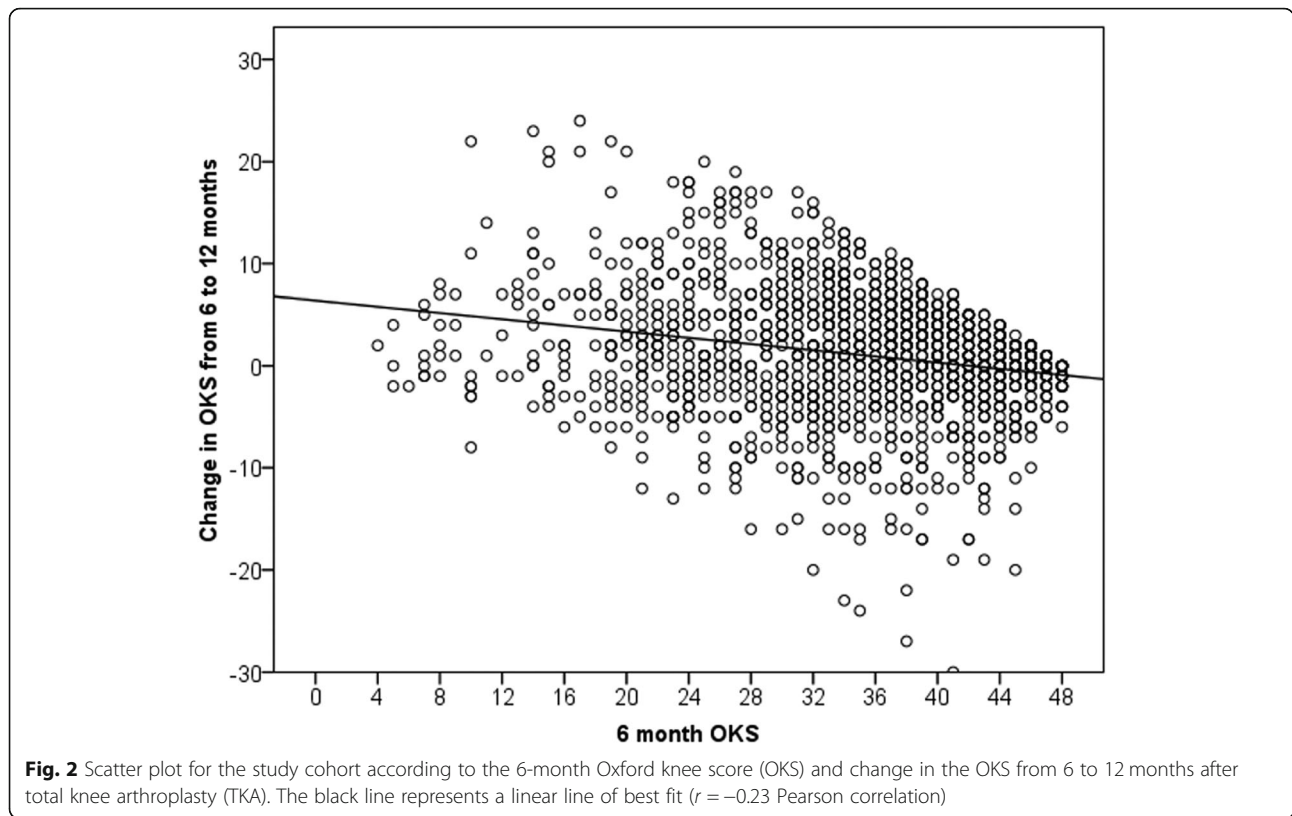
(Table 1). There was a trend toward lower BMI being associated with a greater change in the 6-month to 12-month OKS (Table 1), which was significant after adjusting for confounding (Table 2). A better preoperative OKS resulted in a greater improvement in the OKS from 6 to 12 months (Fig. 1), whereas in contrast, a worse OKS at 6 months resulted in a greater improvement from 6 to 12 months (Fig. 2). Simple linear regression analysis demonstrated that the 6-month OKS influenced the change in the 6-month to 12-month OKS by up to 6.4 (95% CI 5.3–7.6, $p < 0.001$) points, which exceeded the MCID. Using this same regression model, it would

be possible to calculate the change in the OKS between 6 and 12 months using the 6-month OKS: change between 6 and 12 months = 6.4 − (6 months OKS × 0.152).

Change greater than the MCID in the OKS between 6 and 12 months

There were 381 (24.2%) patients that had improvement in the OKS greater than the MCID from 6 to 12 months. However, in contrast 203 (12.9%) patients had a decrease in OKS greater than the MCID from 6 to 12 months. Patients with a change greater than the MCID from 6 to 12 months had a significantly worse 6-month OKS,

Fig. 1 Scatter plot for the study cohort according to the preoperative Oxford knee score (OKS) and change in the OKS from 6 to 12 months after total knee arthroplasty (TKA). The black line represents a linear line of best fit ($r = 0.08$ Pearson correlation)

Fig. 2 Scatter plot for the study cohort according to the 6-month Oxford knee score (OKS) and change in the OKS from 6 to 12 months after total knee arthroplasty (TKA). The black line represents a linear line of best fit ($r = -0.23$ Pearson correlation)

which was significantly better at 12 months when compared to those who did not have a change greater than the MCID (Table 3). After adjusting for confounding, patients with a lower BMI, without diabetes mellitus, with a better preoperative OKS or a worse 6-month OKS were more likely to have an increase in their OKS from 6 to 12 months of greater than the MCID (Table 4). ROC curve analysis showed the 6-month OKS to be a moderately reliable predictor of a MCID improvement in the 6-month to 12-month OKS (Fig. 3), with a threshold value < 36 points being predictive (AUC 0.73, 95% CI 0.70–0.75, $p < 0.001$). In contrast, BMI (AUC 0.53, 95% CI 0.49–0.56, $p = 0.111$) and the preoperative OKS (AUC 0.50, 95% CI 0.47–0.54, $p = 0.996$) were not

reliable predictors of achieving an improvement greater than the MCID (Fig. 4).

Discussion

This study has shown there was a statistically significant change in the OKS from 6 to 12 months after TKA, but this was not clinically significant when assessed as an overall mean change. Patients without diabetes mellitus, with a lower BMI, a better (greater) preoperative OKS, a worse 6-month OKS and a better EQ-5D at 6 months were associated with a greater improvement in the OKS from 6 to 12 months. Nearly a quarter of the patients had a clinically significant improvement in their OKS from 6 to 12 months. Absence of diabetes mellitus or having a 6-

Table 3 Preoperative and postoperative OKS in patients with and without a change greater than the MCID from 6 to 12 months

OKS (mean, SD)	Change greater than MCID		Difference (95% CI)	*P* value*
	Yes (n = 381)	No (n = 1193)		
Preoperative	21.1 (7.6)	21.3 (7.8)	0.2 (−0.7 to 1.1)	0.694
6 Months postoperative	30.4 (7.9)	36.7 (8.9)	6.2 (5.2 to 7.2)	< 0.001
12 Months postoperative	38.8 (7.4)	35.4 (10.1)	3.4 (2.3 to 4.5)	< 0.001

OKS Oxford knee score, *MCID* minimal clinically important difference
*unpaired *t* test

Table 4 Independent predictors of a MCID in the improvement in the OKS from 6 to 12 months after TKA

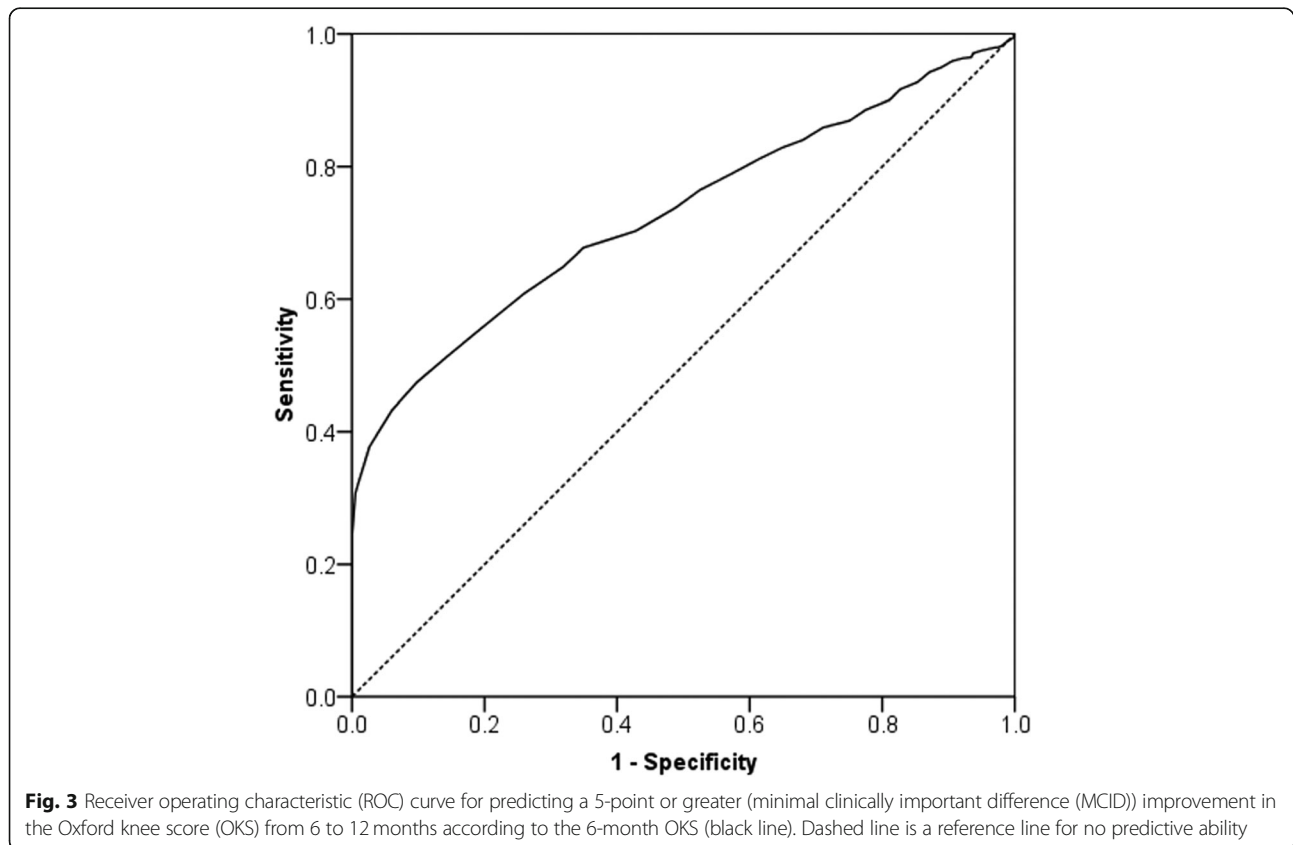| Demographic	Descriptive	Odds ratio	95% CI	*P* value
BMI	For each BMI point	0.97	0.94 to 0.99	0.028
Comorbidity	Not present	Reference*		
	Diabetes mellitus	0.61	0.39 to 0.96	< 0.001
Functional measure				
OKS	Preoperative	1.05	1.02 to 1.07	< 0.001
	6 Months	0.91	0.89 to 0.92	< 0.001

Logistic regression analysis: entering all variables into the model (Table 1) using forward conditional methodology. The R^2 value of the model was 0.10
MCID minimal clinically important difference, *OKS* Oxford Knee Score, *TKA* total knee arthroplasty, *BMI* body mass index, *CI* confidence interval
*Odds ratio relative to a patient without the stated comorbidity

month OKS < 36 points was associated with a clinically significant improvement in the 6 to 12 month OKS.

The statistically significant mean improvement of 1 point demonstrated in the OKS between 6 and 12 months is a novel aspect of this study; however, it is smaller than the 2-point value reported by Browne et al. [7] in their systematic review. Brown et al. [7] compared the mean OKS at 6 months using outcome data taken from Health and Social Care Information Centre in England (n = 30,616) and compared this to 12-month data from 13 published cohort studies. These are non-linked data and may represent a skewed assessment of registry patients (no exclusion criteria) with cohort study data (specific inclusion criteria) that may have resulted in the conclusion of greater improvement. The current study used linked data (same patients) and should represent the real mean change in the OKS experienced by a patient between 6 and 12 months. The MCID in the OKS is 5 points [14] and therefore the 1-point change identified in the current study does not relate to a clinically perceived difference when assessing a cohort of patients between 6 and 12 months after their TKA.

The authors are not aware of a previous publication defining or suggesting the optimal timepoint after TKA when outcome should be assessed using the OKS. This is a fundamental aspect to any study using the OKS; be it a primary or secondary aim, the time of assessment should probably represent the maximal outcome achieved by the patient group being evaluated. The 6-month OKS will likely improve by more than 1 point at 12 months, but in nearly a quarter of patients the improvement will be clinically significant. The recent Total or Partial Knee Arthroplasty Trial (TOPKAT) study assessed the OKS at 5 years after knee arthroplasty as
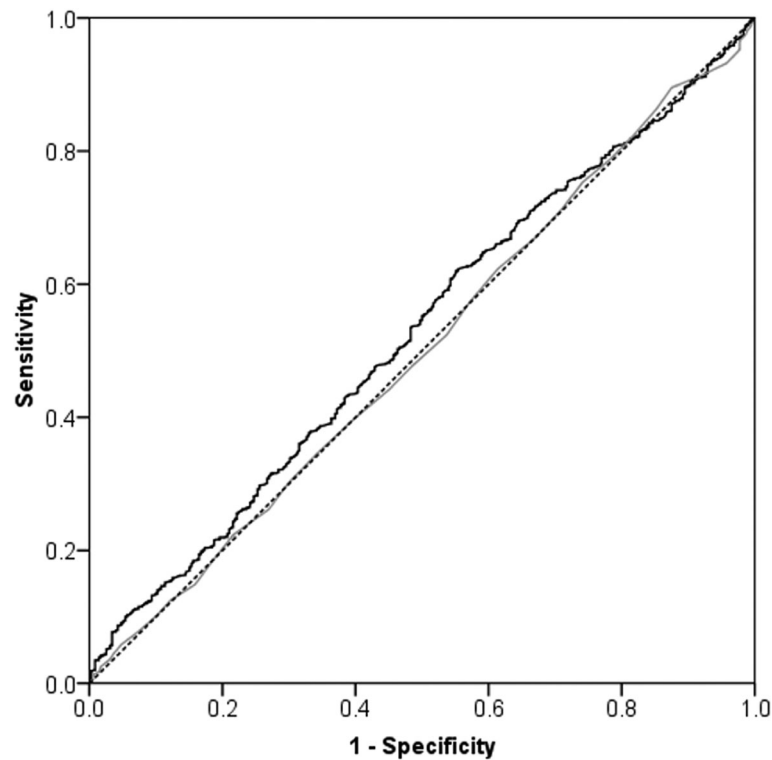

Fig. 3 Receiver operating characteristic (ROC) curve for predicting a 5-point or greater (minimal clinically important difference (MCID)) improvement in the Oxford knee score (OKS) from 6 to 12 months according to the 6-month OKS (black line). Dashed line is a reference line for no predictive ability

Clement *et al. Knee Surgery & Related Research*   (2020) 32:43

Page 7 of 8

Fig. 4 Receiver operating characteristic (ROC) curve for predicting a 5-point or greater (minimal clinically important difference (MCID)) improvement in the Oxford knee score (OKS) from 6 to 12 months according to body mass index (BMI) (black line) and preoperative OKS (grey line). Dashed line is a reference line for no predictive ability

the primary end point, which was not clinically significantly different from that at 1 –5 years in the two groups [10]. This longer follow up of 1–5 years not only delays the results of the study but also adds to the overall cost of the study and potentially increases the loss to follow up. Studies reporting the OKS prior to 1 year, for example those using 6-month data from the National Joint Registry of England and Wales, may not represent the true potential postoperative OKS among patients and may lead to differing conclusions when compared to those studies using data from 1 year onwards. The authors suggest that the 1-year OKS should be used as the benchmark timepoint to assess the outcome of TKA, being the peak score when assessing a cohort of patients.

Despite the current study not demonstrating a clinically significant improvement in the OKS between 6 and 12 months, this does not necessarily mean a patient does not have a clinical improvement in their symptoms and may simply represent a limitation in the OKS to detect such a change. The OKS was originally designed by using feedback from patients waiting to have a TKA and therefore could be more reflective of the preoperative symptom [2]. In contrast, the Forgotten Joint score was designed to be reflective of the postoperative symptom state and Giesinger et al. [15] demonstrated a further

improvement in scores between 1 and 2 years using this tool. Scott el al [8] described a cohort of patients undergoing TKA, who were followed up for 5 years, and found no significant change in the OKS between 1 and 5 years (1-point decrease), suggesting the clinical peak of the OKS after TKA is reached at 1 year.

The relatively short follow up at 1 year is a limitation of this study, as the OKS could potentially change beyond this timepoint. This was due to financial reasons at the study centre with cessation of routine functional outcome collection at this timepoint. Williams et al. [9] demonstrated that the maximal OKS was achieved at 1 year with a score of 34 points, which remained the same until the fifth postoperative year when the OKS fell to 33 points after which there was a gradual decline to 30 points at 10 years after TKA. The observed maximal peak in the OKS between 1 and 4 years demonstrated by Williams et al. [9] supports the results of the current study, with assessment of the peak functional outcome being achieved at 1 year after TKA. A further limitation was the retrospective design of the current study, which did not allow additional assessment of those patients achieving a clinically significant improvement in the OKS between 6 and 12 months. Factors associated with slower recovery during the first 6 months, such as postoperative stiffness or pain in other

Clement *et al. Knee Surgery & Related Research*   (2020) 32:43

Page 8 of 8

joints, may have been identified and accounted for in the analysis [16, 17]. Last, another limitation was that 38.3% of patients were excluded from the analysis due to incomplete OKS questionnaires.

Conclusion

Overall, there was no clinically significant change in the OKS from 6 to 12 months; however, however a clinically significant improvement was observed in approximately a quarter of patients and was more likely among those scoring < 36 points at 6 months.

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