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Does pre-operative Oxford Knee Score (OKS) predict patient reported success six months after total knee arthroplasty?

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Abbreviations

ACORN: Arthroplasty Clinical Outcomes Registry National
AUC: Area Under the Curve
AUD: Australian Dollars
BMI: Body Mass Index
CART: Classification And Regression Tree
QoL: Quality of Life
TKR: Total Knee Replacement

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Abstract

Total knee replacement is a surgical procedure which has revolutionised the treatment of knee osteoarthritis. However, some patients undergoing total knee replacement surgery are not satisfied with the outcome. It is possible that these patients may have received surgery too early or too late in the disease process.

The purpose of this study was to determine whether the Oxford Knee Score can be used as a predictive tool for patient-reported success post total knee replacement. It was hypothesized that patients with a high Oxford Knee Score before surgery, which indicates mild symptoms of disease, were more likely to report poorer patient-reported post-operative success.

This study used a retrospective cohort of prospectively collected data of total knee replacement recipients. Analysis investigated the possible correlation between patient-reported success at six months after surgery with the patients' pre-operative Oxford Knee Score. De-identified dataset of unilateral total knee replacement patients were provided by the Arthroplasty Clinical Outcomes Registry. Overall, 2458 patient records were available for analysis. Estimation of the association between pre-operative Oxford Knee Score and patient-reported success six months post-operatively was performed using logistic regression. Four different models were used for analysis, with Oxford Knee Score treated as continuous and categorical variable; and patient-reported success dichotomised at "much better" and "slightly better". Area Under the Curve were calculated for these models to determine the predictive power. A subsequent secondary analysis was performed investigating correlation between pre-operative Oxford Knee Score and EQ-5D-5L patient-reported Quality of Life measure at six months after surgery using logistic regression analysis. Pre-operative Oxford Knee Score was again treated as a continuous and categorical variable.

Pre-operative Oxford Knee Score was not a significant predictor of patient-reported success (Model 1: P=0.42, Model 2: P=0.51, Model 3: P=0.48, Model 4: P=0.67). Area Under the Curve demonstrated that there was little predictive power in all four models. However, the Oxford Knee Score was a significant predictor of four EQ-5D-5L domains (P<0.001), but not "anxiety and depression". The low Oxford Knee Score group had significantly poorer outcomes (P<0.001) compared to the medium Oxford Knee Score group as reflected in the EQ-5D-5L domains of pain, mobility and usual activities.

This study has demonstrated that pre-operative OKS is not a predictor of patient-reported success at six months. However, patients with a lower Oxford Knee Score pre-operatively are more likely to have poorer results as defined by the EQ-5D-5L. Patients waiting for Total Knee Replacement surgery should avoid deterioration in symptoms to below 26 points as measured by the Oxford Knee Score. Measures should be taken in the pre-operative period to minimise deterioration in disease symptoms.

Keywords: Arthroplasty, Replacement, Knee; Osteoarthritis, Knee; Patient Reported Outcome Measures.

Executive Summary

Context

It is estimated that over 1.6 million (~8% of the population) Australians are affected by osteoarthritis (OA) (AIHW, 2012). This figure is predicted to rise to 11% by the year 2050. Total knee replacement (TKR) surgery is the treatment of choice for end-stage knee OA as it is usually very effective in alleviating pain and improving function. The national number of admissions for TKR has increased at an average of 4.9% per year between 2009/10 and 2013/14 (AIHW, 2014) and is this figure is projected to increase with the aging population.

Implications

As the population aged older than 65 years is projected to increase by 34% in rural Local Health Districts in New South Wales by 2021 (NSW Rural Health Plan, 2014), this operation alone will significantly drain local rural health resources, leading to increased waiting times for elective TKR. This is reflected by the longer median waiting times for TKR surgery at Coffs Harbour Health Campus being 322 days between 2015-16, compared to the national peer median of 282 days (AIHW, 2017). This can potentially impact on the Mid North Coast Local Health District's ability to meet national surgical waiting time targets.

Approach

The aim of this study was to determine if a pre-operative Oxford Knee Score (OKS) was predictive of patient-reported success six months after TKR. Particularly, analysis was performed to establish whether patients with high pre-operative OKS reported poorer outcomes. This would provide support for the optimal time for TKR as indicated by the pre-operative OKS and thereby provide clinicians and policy makers with a tool to guide patients on when to proceed with TKR surgery. Four different models were developed to investigate association between OKS and patient-reported success. Data records for analysis was provided by the Arthoplasty Clinical Outcomes Registry National (ACORN).

Findings

There was no association between pre-operative OKS and patient-reported success six months following TKR. From the four models used for analysis, baseline OKS as either a continuous or categorical variable were not predictive of patient-reported success dichotomised at 'much better' and 'slightly better' at six months post-op (Model 1: P=0.42, Model 2: P=0.51, Model 3: P=0.48, Model 4: P=0.67). Therefore, OKS should not be used as a predictor of post-operative patient-reported success. In addition, there was no evidence to support that patients with high OKS have poorer patient-reported success. However, the accuracy of the results at this high end can be questionable as only 14 out of 2458 participants had OKS >40.

Further analysis found a strong correlation between pre-operative OKS and post-operative EQ-5D-5L, a validated patient-reported Quality of Life (QoL) measure. Analysis using OKS as a continuous variable showed the OKS was a significant predictor of four of the five EQ-5D-

5L domains (P<0.001). The odds of having 'no or slight problems' in the domains of mobility, personal care, usual activities and pain/discomfort increased with every unit increase in baseline OKS. The analysis using categorical OKS found that patients in the low OKS category (0-26) had significantly poorer results than the medium OKS category (27-35) in the QoL domains of pain, mobility and usual activities (P<0.001). There was no correlation between OKS and the other domain of 'anxiety or depression'.

Recommendations

- Processes should be developed to identify patients with an OKS <26 so these patients can undergo expedited surgery to improve post-operative outcomes.
- It is recommended that measures be established to reduce the progression of patients' deteriorating symptoms. Conservative treatment while patients are on the elective surgical waitlist delivered by a physiotherapist and dietitian comprising exercise, education, dietary advice, use of insoles, and pain medication can potentially prevent deterioration in patients' symptoms potentially leading to improved outcomes six months post-operatively.
- Conservative treatment can lead some patients to defer surgery thereby allowing more urgent TKR cases to be performed earlier.
- Due to the low number of patients with high OKS in this investigation, further research into patients with OKS >40 is recommended. In addition, the validity of the success score used by ACORN is another area of further research.
- Further studies should be performed to validate the findings of this study. In particular, future investigations should determine whether OKS <26 represents the optimal time to expedite surgery.

Background

It is estimated that over 1.6 million (~8% of the population) Australians are affected by the commonest form of arthritis - osteoarthritis (OA) (AIHW, 2012). The economic and societal burden of this disease will increase with population ageing. An Access Economics report commissioned for Arthritis Australia (2007) predicted that by the year 2050, 3.1 million Australians (11% of the population) will be affected by OA. In 2007, the direct cost of OA was estimated to be AUD$2 billion. Other indirect financial costs such as loss of productivity, absenteeism, informal care and equipment costs were estimated to reach $AUD 7.6 billion. A report released by the Centre of National Research on Disability and Rehabilitation Medicine on behalf of the National Arthritis and Musculoskeletal Conditions Advisory Group predicted that on current trends, OA will become the fourth leading cause of worldwide disability by the year 2020.

National action plans have been developed to address the public health issue posed by OA. In 2002, the Australian Government identified arthritis and other musculoskeletal conditions as a national health priority and established the National Arthritis and Musculoskeletal Conditions Advisory Group (NAMSCAG, 2004). This group developed a National Action Plan and a National Service Improvement Framework for conditions such as OA.

One of the most commonly involved joint affected by OA is the knee (Arden & Nevitt, 2006). Total Knee Replacement (TKR) is a surgical treatment for people with symptomatic OA which can dramatically reduce pain and improve function. As the incidence of OA in the population increases, the number of TKR surgeries has also increased. Between 2009/10 and 2013/14 in Australia, the number of admissions for TKR has increased on average 4.9% per year between (AIHW, 2014). As the population aged older than 65 years is projected to increase by 34% in rural NSW Local Health Districts by 2021 (NSW Rural Health Plan, 2014), it is predicted that demand for TKR will increase the strain on rural health services and increase the waiting times for TKR surgery.

While TKR is accepted as a management option for arthritis of the knee, not all patients are satisfied with the outcome of a TKR (Scott, Howie, MacDonald, & Biant, 2010). In the 2014 Arthroplasty Clinical Outcomes Registry report, 11% of 752 patients after elective TKR surgery were not satisfied with their outcome and 9% did not feel their surgery was successful.

Patients who present for joint surgery vary widely in disease severity and functional disability. Some patients have very mild symptoms of pain and disability, while others can have severe symptoms. It is postulated that patients with mild or severe functional disability may have poorer post-surgical outcomes. Answering the proposed clinical question may help patients with mild symptoms to make an informed decision on whether to proceed with surgery particularly if the patient is undecided. It may also assist with identification of more severe patients to expedite TKR surgery to prevent poor post-operative outcomes.

Fortin et al (2002) found that patients with poorer baselines (as measured by the Western Ontario and McMaster Universities Osteoarthritis Index) (WOMAC) had poorer outcomes

two years post-operatively. Jones et al (2006) also found that patients with poorer pre-operative scores using the WOMAC and SF-36 self-reported questionnaires required more intensive rehabilitation to restore physical function. Lim et al (2006) demonstrated that patients with low pre-operative Oxford Knee Score (OKS) did not consistently achieve high post-operative OKS. Kahn et al (2013) further showed a correlation between pre-operative WOMAC scores and post-operative WOMAC scores. A study by Judge et al (2012) confirmed that patients with better pain and function pre-operatively as determined by the OKS had better post-operative results. They also reported a potential ceiling effect for patients with high OKS of 40 or more. Twenty-four patients had an OKS >40. Of these 24 patients, ten improved, three stayed the same and 11 were worse post-operatively. However, it is unclear why the score of 40 was used as a cut off.

Patient-reported success and satisfaction are used in research and registry databases to assess outcomes from the patient's perspective. A number of studies have investigated patient-reported outcomes of satisfaction after TKR surgery. Scott et al (2010) found that satisfied patients had a greater increase in OKS at 6 months post-operatively. Judge et al (2012) found that patients with more severe pain and reduced function pre-operatively require a larger change in OKS to achieve the highest levels of satisfaction. Clement et al (2013) were able to correlate post-operative OKS to patients' satisfaction post-operatively and proposed a new categorisation related to patient satisfaction; OKS above 36 "very satisfied", 27- 35 "satisfied" and below 26 as "dissatisfied".

However, patient-reported satisfaction can be unreliable in determining surgical outcomes. Judge et al (2012) demonstrated that of 143 patients who had no change or worse symptoms post-operatively (as defined by change in pre- and post-op OKS), 78 (54.6%) were still satisfied with surgical outcomes. No studies to date have investigated the correlation between pre-operative OKS and patient-reported success of the surgery.

The absolute OKS is believed to decrease with increasing age (Bremner-Smith, Ewings, & Weale, 2004; Murray et al., 2007). The minimally clinical important difference in the OKS following TKR is probably 5.0 and 4.3 for pain and function respectively (Clement, MacDonald, & Simpson, 2014). Therefore, the capacity for improvement in people undergoing TKR with high OKS may be limited.

Therefore, the hypothesis of this study is that patients with high OKS Pre-operatively have poorer patient-reported success due to a lower capacity of change possible in the OKS (a ceiling or saturation effect on the OKS scale).

Research Aim and Objectives

Aim:

The primary aim of this project was to determine whether pre-operative OKS were predictive of patients' self-reported post-operative success six months after TKR surgery.

Objectives:

The primary objective of this study is to determine if patients with high pre-operative OKS have poorer self-reported success post-operatively.
The secondary objective is to determine whether a threshold pre-operative OKS exists where patients would be more likely report poor success.

Method

Study Design

A retrospective cohort utilising pre-operative and six months post-operative data for 2458 patients from the Arthroplasty Clinical Outcomes Registry National (ACORN) who underwent an elective unilateral TKR was identified. This registry commenced in 2012 and receives data from eight institutions. The inaugural year of ACORN data collection was excluded to potentially improve data quality. Inclusion and exclusion criteria of this study are:

Inclusion criteria

1. Data registered in the ACORN database
2. Elective primary unilateral TKR surgery
3. Complete data pre-operatively and six months post-operatively
4. Date of surgery between 1/1/13 to 31/12/15

Exclusion criteria

1. Bilateral, unicondylar and revision TKR surgeries
2. Incomplete datasets

Ethics

Approval from the North Coast New South Wales Human Research Ethics Committee as Low/-Negligible Risk project was obtained (HREC no: LNR136). Governance approval was granted by the Mid North Coast Research Governance Office (LNRSSA/16/NCC/).

Outcome measures

Once all approvals were received, application was then made to ACORN for access to de-identified data held in ACORN. The following de-identified data was obtained:

- Demographic data (i.e. insurance status, highest year of education, age, gender)

- Height and weight
- Co-morbidity data and medical history
- Expectations of outcome
- Surgical details
- Complications during admission
- Discharge status and length of stay
- Complications post discharge
- Reoperation
- Readmission
- Patient-reported satisfaction post discharge
- Patient-reported success post discharge
- Pre-operative and post-operative OKS
- Pre-operative and post-operative Quality of Life (QoL) survey (EQ-5D-5L)

No patient identifiable information (such as name, address, date of birth, Medical Record Number) or information on the identity of the surgeon or hospital at which the patient was treated, was provided. Precision of other data items, such as age, was limited to whole years to preserve anonymity of the data set.

The primary predictor of interest was the OKS. The OKS consists of 12 questions assessed on a Likert scale with values from 0-4 (see appendix 2). A summative score is then calculated where 48 is the best possible score (least symptomatic) and 0 is the worst possible score (most symptomatic). It has excellent test-retest reliability and validity (Harris et al, 2013).

The primary outcome was patient-reported success at six months post-TKR. The question asked by ACORN is "overall, how are the problems now with your knee on which you had surgery, compared to before your operation?" Five possible response options available are: much better; a little better; about the same; a little worse; and much worse.

A secondary outcome of interest was the QoL survey EQ-5D-5L at six months post TKR. The EQ-5D-5L involves five domains: anxiety or depression; pain and discomfort; personal care; mobility; and ability to perform usual activities. Responses for the 'personal care' QoL domain were 'No problems washing or dressing', 'Slight problems washing or dressing', 'Moderate problems washing or dressing', 'Severe problems washing or dressing', and 'Unable to do washing or dressing'. The remaining QoL domains were scored similarly (see appendix 3). The EQ-5D-5L has been shown to have good convergent validity (Janssen et al, 2013).

Data Management

Data was transferred via secure electronic methods (i.e. encryption and password protected) and stored in an electronic folder at Coffs Harbour Health Campus, within the NSW Health Information Technology environment. It is only accessible by investigators conducting this research. Any data analysis was conducted on a copy of the original data provided by ACORN to minimise the risk of altering the original dataset.

Primary Analysis

Patient-reported success was defined using two dichotomies, the first using 'much better' as the cut point for success, the second using 'a little better'. Pre-operative OKS was analysed as both a continuous measure and a categorical variable (0-26 (low), 27-35 (medium), and 36-48 (high)). This categorical system is based on a previous study by Clement et al (2013). Other potential confounders measured included age at baseline (years), Body Mass Index (BMI, kg/m2), education (< year 10, year 11-12, trade/diploma, and higher education), and gender.

The crude effect of baseline OKS on each definition of success was estimated using logistic regression. Model 1 utilized the first definition of success (i.e. 'much better' as the cut-point) and OKS as a continuous variable. Model 2 utilized the second definition of success (i.e. 'a little better' as the cut-point) and OKS as a continuous variable. Model 3 utilized the first definition of success and OKS as a categorical variable. Model 4 utilized the second definition of success and OKS as a categorical variable. For each model the effect of other baseline demographic characteristics (age, BMI, education, and sex) on success were explored. Area under the curve (AUC) was calculated for each model to determine predictive power.

In addition, possible relevant confounders at baseline (see Tables 7 and 8 of the Appendix 1), and the OKS, as a continuous variable were included in the Classification and Regression Tree (CART) models to determine the variables most likely to be predictive of patient-reported success. The significant measures of 'discharge destination' was omitted as this variable occurred after the baseline measure. Including this measure in the regression analysis may potentially have confounded the results of this study. Other significant measures (i.e. comorbidities) from the CART model were excluded as they were found to be non-significant in the multivariate models.

Secondary Analysis

Further to the primary analysis, other outcomes from ACORN were analysed for possible correlation with pre-operative OKS. As part of this secondary analysis, the relationship between baseline OKS and patient-reported QoL at six months post-surgery, as measured by EQ-5D-5L was investigated. The outcome was dichotomized into 'No problems' or 'Slight problems' versus 'Moderate', 'Severe' or 'Unable to do'. The remaining QoL domains were dichotomized similarly. Responses of 'NA' or 'Unknown/Not stated' were treated as missing.

The effect of baseline OKS on each of the five QoL domains was then explored using logistic regression adjusted for baseline QoL. Two models were run for each domain, utilizing the continuous and categorized OKS respectively. For each outcome model, the effect of other baseline demographic characteristics (i.e. age, BMI, education, and sex) were explored. The predictive power for each model were calculated using AUC

Statistical analyses were programmed using SAS v9.4 (SAS Institute, Cary, North Carolina, USA). In both analysis, missing data was dealt with using case wise deletion in the logistic regressions.

Results

Demographic characteristics displayed in Table 1 were found to be consistent with that of other studies investigating TKR population (Fortin et al., 2002; Judge et al., 2012; Kahn et al., 2013; Rothwell et al., 2010).

Table 1: Baseline patients demographic parameters (N=2458)

Variable		
Primary Diagnosis, N (%)		
	Osteoarthritis	2338 (95.1)
	Other	49 (2)
	Missing	71 (2.9)
Gender, N (%)		
	Female	1586 (64.5)
	Male	872 (35.5)
Number of Co-morbidities, N (%)		
	0	288 (11.7)
	1	458 (18.6)
	2	644 (26.2)
	3	510 (20.8)
	4	310 (12.6)
	5+	248 (10.1)
BMI (N = 2322), Mean (SD)		33.0 (6.7)
Age (N = 2453), Mean (SD)		69.1 (9.1)

Primary Analysis

Table 2a displays the results of the crude and adjusted logistic regression of success on continuous OKS (Models 1 and 2 – see method), and Table 2b displays the results of the crude and adjusted logistic regression of success on categorical OKS (Models 3 and 4 – see method).

Table 2a: Success at 6 months Inference (Continuous OKS)

Outcome	Predictor	Unadjusted OR (95%CI) (N=2029)	P-value	Adjusted OR (95% CI) (N=1823)	P-value
Model 1: Success (cut off point 'much better')	OKS (continuous)	1.00 (0.99, 1.01)	0.91	0.99 (0.98, 1.01)	0.42
	Age	-	-	1.01 (1.01, 1.03)	0.08
	Gender:				
	Male	-	-	Ref	0.80
	Female	-	-	0.97 (0.75, 1.24)	
	BMI		-	1.00 (0.98, 1.02)	0.73
	Education:				
	<= year 10	-	-	Ref	0.29
	Year 11-12	-	-	1.21 (0.76, 0.93)	
	Trade/Diploma	-	-	1.18 (0.89, 1.56)	
	higher education	-	-	1.71 (0.90, 3.23)	
Model 2: Success (cut off point 'A little better'	OKS (continuous)	1.00 (0.98, 1.02)	0.88	0.99 (0.97, 1.02)	0.51
	Age	-	-	1.00 (0.98, 1.03)	0.67
	Gender:				
	Male	-	-	Ref	0.67
	Female	-	-	0.92 (0.63, 1.35)	
	BMI	-	-	0.99 (0.96, 1.01)	0.25
	Education				

Outcome	Predictor	Unadjusted OR (95%CI) (N=2029)	P-value	Adjusted OR (95% CI) (N=1823)	P-value
	<= year 10	-	-	Ref	0.27
	Year 11-12	-	-	1.70 (0.77, 3.77)	
	Trade/Diploma	-	-	1.18 (0.78, 1.80)	
	Higher Education	-	-	2.47 (0.76, 8.07)	

Table 2b: Success at 6 months Inference (Categorical)

Outcome	Predictor	Unadjusted OR (95%CI) (N=2029)	P-value	Adjusted OR (95% CI) (N=1823)	P-value
Model 3: Success (cut off point 'much better')	OKS				
	Medium	Ref	0.46	Ref	0.48
	Low	1.06 (0.79, 1.43)		1.15 (0.84, 1.59)	
	High	1.71 (0.73, 3.99)		1.61 (0.68, 3.78)	
	Age	-	-	1.01 (1.00, 1.03)	0.08
	Gender:				
	Male	-	-	Ref	0.87
	Female	-	-	0.98 (0.76, 1.26)	
	BMI		-	1.00 (0.98, 1.02)	0.80
	Education:				
	<= year 10	-	-	Ref	0.32
	Year 11-12	-	-	1.21 (0.76, 1.93)	
	Trade/Diploma	-	-	1.16 (0.88, 1.53)	
	higher education	-	-	1.69 (0.83, 3.21)	
Model 4: Success (cut off point 'A little better'	OKS				
	Medium	Ref	0.99	Ref	0.67
	Low	1.03 (0.65, 1.61)		1.22 (0.76, 1.96)	
	High	1.00 (0.33, 3.03)		0.97 (0.32, 2.97)	
	Age	-	-	1.00 (0.98, 1.03)	0.67
	Gender:				
	Male	-	-	Ref	0.67
	Female	-	-	0.92 (0.63, 1.35)	
	BMI	-	-	0.99 (0.96, 1.01)	0.26
	Education				
	<= year 10	-	-	Ref	0.27
	Year 11-12	-	-	1.71 (0.77, 3.78)	
	Trade/Diploma	-	-	1.18 (0.78, 1.80)	
	Higher Education	-	-	2.48 (0.76, 8.10)	

Table 3 displays the AUC for each of the models. The logistic regression of success (defined using two alternative cut-points) was not found to be significantly associated with the OKS (either continuous or categorized). CART models were implemented to try to determine the optimal cut-point for the OKS that would predict success. The OKS was not found to be a significant predictor of self-rated success. The AUC scores also indicated very low predictive power in these models.

Table 3: AUC for 'success' inference

Variables for predictor model	Unadjusted AUC (95% CI)	Adjusted AUC (95%CI)
1. Continuous OKS vs success cut off point 'much better'	0.51 (0.49, 0.53)	0.54 (0.51, 0.57)
2. Continuous OKS vs success cut off point 'A little better'	0.51 (0.48, 0.54)	0.55 (0.51, 0.60)
3. Categorical OKS vs success cut off point 'much better'	0.51 (0.49, 0.53)	0.54 (0.51, 0.58)
4. Categorical OKS vs success cut off point 'A little better'	0.50 (0.47, 0.53)	0.56 (0.51, 0.60)

Secondary Analysis

The results of the baseline adjusted and fully adjusted logistic regression of each QoL domain on the continuous OKS are displayed in Table 4a, and the associated AUC values in Table 4b. The OKS was a significant predictor of all the EQ-5D-5L domains except 'anxiety or depression' (at a significance level of alpha = 0.05). The (fully adjusted) odds of having 'no or slight' problems washing or bathing, increased by 5% for every unit increase in baseline OKS. The (fully adjusted) odds of having 'no or slight' pain or discomfort increased by 4% for every unit increase in baseline OKS. The (fully adjusted) odds of having 'no or slight' problems doing usual activities increased by 6% for every unit increase in baseline OKS. The (fully adjusted) odds of having 'no or slight' mobility problems increased by 4% for every unit increase in baseline OKS.

Table 4a: Baseline adjusted inference of EQ5D QoL Inference on Continuous OKS

Outcomes	Predictor	Baseline adjusted OR (95%CI)	P-value	Fully adjusted OR (95%CI)	P-value
Anxiety or Depression (N=2008 baseline unadjusted, N = 1805 fully adjusted)	OKS	1.02 (1.00, 1.04)	0.09	1.01 (0.99, 1.04)	0.25
	Baseline Anxiety				
	Not anxious/depressed	Ref	<0.01	Ref	<0.001
	Slightly anxious/depressed	0.49 (0.30, 0.81)		0.50 (0.30, 0.83)	
	Moderately anxious/depressed	0.22 (0.14, 0.35)		0.24 (0.15, 0.39)	
	Extremely anxious/depressed	0.07 (0.04, 0.14)		0.09 (0.04, 0.19)	
	Severely anxious/depressed	0.14 (0.08, 0.24)		0.15 (0.09, 0.27)	
	Age	-	-	1.02 (1.00, 1.04)	0.037
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.78 (0.54, 1.14)	0.20
	BMI	-	-	1.00 (0.98, 1.03)	0.93
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.65 (0.37, 1.13)	0.31
	Trade/Diploma	-	-	1.04 (0.69, 1.57)	
	Higher education	-	-	1.55 (0.59, 4.06)	
Washing or dressing (N=2009 baseline adjusted, N=1807 fully adjusted)	OKS	1.05 (1.02, 1.08)	<0.001	1.05 (1.02, 1.09)	<0.001
	Baseline washing/dressing				
	No problem	Ref		Ref	
	Slight problems	0.62 (0.36, 1.07)	<0.001	0.63 (0.35, 1.14)	<0.001
	Moderate problems	0.42 (0.25, 0.72)		0.42 (0.23, 0.74)	
	Severe problems	0.27 (0.14, 0.52)		0.28 (0.14, 0.58)	
	Cannot do	0.54 (0.06, 4.58)		0.45 (0.05, 3.92)	
	Age	-	-	0.99 (0.97, 1.01)	0.30
	Gender				
	Male	-	-	Ref	
	Female	-	-	1.61 (1.08, 2.40)	0.02
	BMI	-	-	0.96 (0.93, 0.98)	<0.001
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.85 (0.42, 1.73)	0.71
	Trade/Diploma	-	-	0.79 (0.50, 1.24)	
	Higher education	-	-	0.72 (0.29, 1.79)	
Pain or discomfort (N=2012 baseline adjusted, N=1810 fully adjusted)	OKS	1.06 (1.04, 1.08)	<0.001	1.04 (1.02, 1.07)	<0.001
	Baseline pain or discomfort				
	None	Ref		Ref	
	Slight	0.47 (0.11, 2.13)	0.49	0.60 (0.13, 2.71)	0.63
	Moderate	0.39 (0.09, 1.68)		0.45 (0.10, 1.95)	
	Severe	0.44 (0.10, 1.95)		0.46 (0.10, 2.03)	
	Extreme	0.47 (0.10, 2.14)		0.43 (0.09, 2.01)	

Outcomes	Predictor	Baseline adjusted OR (95%CI)	P-value	Fully adjusted OR (95%CI)	P-value
	Age	-	-	1.01 (0.99, 1.02)	0.39
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.73 (0.57, 0.92)	<0.01
	BMI	-	-	0.99 (0.97, 1.00)	0.09
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.95 (0.63, 1.44)	0.50
	Trade/Diploma	-	-	0.94 (0.73, 1.23)	
	Higher education	-	-	1.50 (0.84, 2.68)	
Usual activities (N=2011 baseline adjusted, N=1810 fully adjusted)	OKS	1.06 (1.04, 1.09)	<0.001	1.06 (1.03, 1.08)	<0.001
	Baseline usual activities				
	No problems	Ref		Ref	
	Slight problems	0.63 (0.29, 1.37)	0.28	0.53 (0.22, 1.28)	0.20
	Moderate problems	0.58 (0.27, 1.25)		0.44 (0.18, 1.05)	
	Severe problems	0.46 (0.20, 1.03)		0.36 (0.14, 0.89)	
	Unable to do	0.56 (0.22, 1.41)		0.43 (0.15, 1.19)	
	Age	-	-	1.00 (0.98, 1.01)	0.87
	Gender				
	Male	-	-	Ref	
	Female	-	-	1.03 (0.78, 1.37)	0.82
	BMI	-	-	0.97 (0.96, 0.99	<0.001
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	1.06 (0.63, 1.79)	0.43
	Trade/Diploma	-	-	0.78 (0.57, 1.07)	
	Higher education	-	-	0.92 (0.49, 1.74)	
Mobility (N=2010 baseline adjusted, N=1805 fully adjusted)	OKS	1.05 (1.03, 1.07)	<0.001	1.04 (1.02, 1.06)	<0.001
	Baseline mobility				
	No problems	Ref		Ref	
	Slight problems	0.72 (0.32, 1.60)	0.52	0.66 (0.27, 1.65)	0.15
	Moderate problems	0.67 (0.31, 1.43)		0.50 (0.21, 1.19)	
	Severe problems	0.55 (0.25, 1.23)		0.40 (0.16, 1.00)	
	Unable to do	0.54 (0.17, 1.76)		0.65 (0.16, 2.76)	
	Age	-	-	1.00 (0.99, 1.02)	0.84
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.97 (0.75, 1.27)	0.83
	BMI	-	-	0.98 (0.96, 1.00)	0.05
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.93 (0.58, 1.48)	0.33
	Trade/Diploma	-	-	0.77 (0.57, 1.02)	
	Higher education	-	-	1.04 (0.56, 1.93)	

Table 4b: AUC for QoL logistic regression on continuous OKS

Dependent variable - Domains of EQ5D5L	Unadjusted AUC (95%CI)	Adjusted AUC (95%CI)
Anxiety or depression	0.74 (0.70, 0.77)	0.73 (0.70, 0.77)
Washing or bathing	0.70 (0.66, 0.74)	0.72 (0.68, 0.76)
Pain or discomfort	0.62 (0.59, 0.65)	0.63 (0.60, 0.65)
Usual activities	0.66 (0.63, 0.69)	0.66 (0.63, 0.70)
mobility	0.63 (0.60, 0.66)	0.64 (0.61, 0.67)

The results of the baseline adjusted and fully adjusted logistic regression of each QoL domain on the categorized OKS are displayed in Table 5a, and the associated AUC values in Table 5b. The effect could not be estimated for the effect of having a 'high' OKS on the washing and bathing QoL domain, and the effect of the OKS on the anxiety/depression QoL domain was non-significant. The (fully adjusted) odds of having 'no or slight' pain or discomfort was significantly lower for those with low OKS compared to those with medium OKS (OR = 0.49), and the odds for those with high OKS was (non-significantly) higher compared to those with medium scores (OR = 3.02). The (fully adjusted) odds of having 'no or slight' problems conducting their usual activities was significantly lower for those with low OKS compared to those with medium OKS (OR = 0.41), and the odds for those with high OKS was (non-significantly) higher compared to those with medium scores (OR = 2.38). The (fully adjusted) odds of having 'no or slight' mobility problems was significantly lower for those with low OKS compared to those with medium OKS (OR = 0.54), and the odds for those with high OKS was (non-significantly) higher compared to those with medium scores (OR = 3.96).

Table 5a: Baseline adjusted inference of EQ5D QoL Inference on Categorical OKS

Outcomes	Predictor	Baseline adjusted OR (95%CI)	P-value	Fully adjusted OR (95%CI)	P-value
Anxiety or Depression (N=2008 baseline unadjusted, N = 1805 fully adjusted)	OKS				
	Medium	Ref	0.41	Ref	0.65
	Low	0.73 (0.40, 1.35)		0.86 (0.46, 1.60)	
	High	1.90 (0.24, 15.0)		2.00 (0.25, 15.8)	
	Baseline Anxiety				
	Not anxious/depressed	Ref	<0.001	Ref	<0.001
	Slightly anxious/depressed	0.50 (0.30, 0.82)		0.50 (0.30, 0.83)	
	Moderately anxious/depressed	0.21 (0.13, 0.34)		0.23 (0.14, 0.38)	
	Extremely anxious/depressed	0.06 (0.03, 0.12)		0.08 (0.04, 0.17)	
	Severely anxious/depressed	0.13 (0.08, 0.22)		0.14 (0.08, 0.25)	
	Age	-	-	1.02 (1.00, 1.04)	0.04
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.77 (0.53, 1.11)	0.16
	BMI	-	-	1.00 (0.98, 1.02)	0.99
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.65 (0.37, 1.13)	0.30
	Trade/Diploma	-	-	1.04 (0.69, 1.57)	
	Higher education	-	-	1.55 (0.59, 4.06)	
Washing or dressing (N=2009 baseline adjusted, N=1807 fully adjusted)	OKS				
	Medium	Ref	0.03	Ref	0.08
	Low	0.26 (0.09, 0.72)		0.30 (0.11, 0.86)	
	High	NA*		NA*	
	Baseline washing/dressing				
	No problem	Ref		Ref	
	Slight problems	0.63 (0.37, 1.08)	<0.001	0.63 (0.35, 1.12)	<0.001
	Moderate problems	0.38 (0.23, 0.61)		0.36 (0.21, 0.61)	
	Severe problems	0.19 (0.11, 0.33)		0.19 (0.10, 0.35)	
	Cannot do	0.42 (0.05, 3.46)		0.38 (0.04, 3.24)	
	Age	-	-	0.99 (0.97, 1.01)	0.35
	Gender				
	Male	-	-	Ref	
	Female	-	-	1.50 (1.01, 2.22)	0.04
	BMI	-	-	0.95 (0.93, 0.98)	<0.001
	Education				
	<= year 10	-	-	Ref	

Outcomes	Predictor	Baseline adjusted OR (95%CI)	P-value	Fully adjusted OR (95%CI)	P-value
	Year 11-12	-	-	0.85 (0.42, 1.73)	0.75
	Trade/Diploma	-	-	0.81 (0.51, 1.27)	
	Higher education	-	-	0.71 (0.29, 1.75)	
Pain or discomfort (N=2012 baseline adjusted, N=1810 fully adjusted)	OKS				
	Medium	Ref	<0.001	Ref	<0.001
	Low	0.41 (0.28, 0.61)		0.49 (0.33, 0.73)	
	High	3.01 (0.69, 13.1)		3.02 (0.69, 13.2)	
	Baseline pain or discomfort				
	None	Ref		Ref	
	Slight	0.47 (0.10, 2.15)	0.04	0.62 (0.13, 2.90)	0.06
	Moderate	0.39 (0.09, 1.72)		0.50 (0.11, 2.25)	
	Severe	0.33 (0.07, 1.44)		0.42 (0.09, 1.88)	
	Extreme	0.25 (0.06, 1.14)		0.32 (0.07, 1.48)	
	Age	-	-	1.01 (0.99, 1.02)	0.38
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.70 (0.55, 0.88)	<0.001
	BMI	-	-	0.98 (0.97, 1.00)	0.06
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.94 (0.62, 1.42)	0.54
	Trade/Diploma	-	-	0.95 (0.73, 1.23)	
	Higher education	-	-	1.47 (0.82, 2.62)	
Usual activities (N=2011 baseline adjusted, N=1810 fully adjusted)	OKS				
	Medium	Ref	<0.001	Ref	<0.001
	Low	0.35 (0.20, 0.61)		0.41 (0.23, 0.73)	
	High	2.47 (0.32, 19.3)		2.38 (0.30, 18.8)	
	Baseline usual activities				
	No problems	Ref		Ref	
	Slight problems	0.65 (0.30, 1.45)	<0.001	0.55 (0.22, 1.36)	<0.001
	Moderate problems	0.56 (0.26, 1.21)		0.43 (0.18, 1.02)	
	Severe problems	0.31 (0.15, 0.68)		0.26 (0.11, 0.64)	
	Unable to do	0.32 (0.13,0.75)		0.27 (0.10, 0.71)	
	Age	-	-	1.00 (0.98, 1.01)	0.94
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.96 (0.73, 1.27)	0.78
	BMI	-	-	0.97 (0.95, 0.99)	<0.001
	Education				
	<= year 10	-	-	Ref	
	Year 11-12	-	-	1.06 (0.63, 1.78)	0.55
	Trade/Diploma	-	-	0.81 (0.59, 1.10)	
	Higher education	-	-	0.92 (0.49, 1.75)	
Mobility (N=2010 baseline adjusted, N=1805 fully adjusted)	OKS				
	Medium	Ref	<0.001	Ref	<0.001
	Low	0.45 (0.29, 0.71)		0.54 (0.34, 0.88)	
	High	4.32 (0.57, 33.0)		3.96 (0.51, 30.6)	
	Baseline mobility				
	No problems	Ref		Ref	
	Slight problems	0.79 (0.35, 1.78)	<0.001	0.74 (0.29, 1.86)	<0.001
	Moderate problems	0.70 (0.32, 1.52)		0.54 (0.22, 1.30)	
	Severe problems	0.43 (0.20, 0.93)		0.35 (0.14, 0.84)	
	Unable to do	0.34 (0.11, 1.05)		0.49 (0.12, 1.98)	
	Age	-	-	1.00 (0.99, 1.02)	0.72
	Gender				
	Male	-	-	Ref	
	Female	-	-	0.93 (0.71, 1.21)	0.59
	BMI	-	-	0.98 (0.96, 1.00)	0.03
	Education				

Outcomes	Predictor	Baseline adjusted OR (95%CI)	P-value	Fully adjusted OR (95%CI)	P-value
	<= year 10	-	-	Ref	
	Year 11-12	-	-	0.91 (0.57, 1.46)	0.37
	Trade/Diploma	-	-	0.78 (0.58, 1.04)	
	Higher education	-	-	1.05 (0.56, 1.93)	

*Unable to estimate

Table 5b: AUC for QoL logistic regression on categorical OKS

Dependent variable - Domains of EQ5D5L	Unadjusted AUC (95%CI)	Adjusted AUC (95%CI)
Anxiety or depression	0.73 (0.70, 0.77)	0.73 (0.70, 0.77)
Washing or bathing	0.69 (0.65, 0.73)	0.71 (0.67, 0.76)
Pain or discomfort	0.60 (0.57, 0.62)	0.62 (0.60, 0.65)
Usual activities	0.64 (0.61, 0.67)	0.65 (0.62, 0.68)
mobility	0.62 (0.59, 0.64)	0.63 (0.60, 0.66)

Further analysis investigated the relationship between pre-operative and post-operative OKS. Improvement in OKS was defined as six months post-op OKS greater than the baseline OKS, and worsening/no improvement was defined as a 6 month OKS less than or equal to the baseline OKS. One thousand and sixty one patients (96.5%) reported an improvement from baseline OKS. Seventy-one patients (3.5%) reported no or worsening of OKS from baseline.

Improvement in OKS was then compared to self-reported success at 6-months follow- up using chi-squared analyses. Table 6a cross tabulates improvement with success (defined as 'much better',) and Table 6b with success (defined as 'a little better' or 'much better'). In both cases, there was a significant association between improvement in the OKS and success (Table 6a: $\chi^2 = 181.1$, $p < 0.001$, table 6b: $\chi^2 = 296.6$, $P<0.01$)

Table 6a: Improvement versus success ('much better')

	Unsuccessful	Successful defined by cut off as "much better"	Total
No change or worsen OKS at 6 months post-op	60 (3.0%)	10 (0.5%)	70 (3.5%)
Improvement in OKS at 6 months post op	366 (18.2%)	1577 (78.3%)	1943 (96.5%)
Total	426 (21.2%)	1587 (78.8%)	2013 (100%)

Table 6b: Improvement versus success ('much better' or 'a little better')

	Unsuccessful	Successful defined by cut off as "a little better"	Total
No change or worsen OKS at 6 months post-op	44 (2.2%)	26 (1.3%)	70 (3.5%)
Improvement in OKS at 6 months post op	117 (5.8%)	1826 (90.7%)	1943 (96.5%)
Total	161 (8.0%)	1852 (92.0%)	2013 (100%)

Discussion

The hypothesis of this research was that OKS at baseline would predict patient-reported success at six months after TKR surgery. It was further hypothesized that high OKS to be associated with lower patient-reported success. It has also been demonstrated that patients who are satisfied with the outcomes of TKR surgery are more likely to have improvements in OKS from baseline (Judge et al., 2012; Scott, Howie, MacDonald, & Biant, 2010). The analysis of this study has supported this finding showing there was a significant association between improvement in the OKS and patient-reported success.

However, the absolute OKS is believed to decrease with increasing age (Bremner-Smith, Ewings, & Weale, 2004; Murray et al., 2007). In addition, it is proposed that the minimally clinical important difference in the OKS following TKR are estimated to be 5.0 and 4.3 for pain and function respectively (Clement, MacDonald, & Simpson, 2014). Therefore, the capacity for improvement in people undergoing TKR with high OKS may be limited. However, the logistic regression of success (defined using two alternative cut-points) was not found to be significantly associated with the OKS (either continuous or categorized). This study has found that there is no association between patients with a high baseline OKS and patient-reported success. An inference can be made that patients who have mild or very mild symptoms can have positive outcomes six months after TKR surgery.

A study conducted by Judge et al (2012) in the United Kingdom reported a potential ceiling effect for patients with high OKS of 40 or more. In Judge's study, 24 (1.2%) patients had an OKS >40. Of these 24 patients, ten improved, three stayed the same and 11 were worse post-operatively. The hypothesis by Judge and his colleagues cannot be supported by the findings of this study. In this current study comprising of 2458 records, only 14 (0.6%) patients had a pre-operative OKS of >40. Of these, 13 patients improved and one stayed the same. This suggests that there may be differences between patients undergoing TKR in the United Kingdom and Australia. Alternatively, it may reflect that surgeons included in ACORN are adequately identifying those patients who will most benefit from surgery.

The secondary analysis, which looked at self-rated QoL as measured by the EQ-5D-5L, a standardized measure of health outcomes, found significant associations between pre-operative OKS and post-operative QoL. When the OKS was included as a continuous measure, it was a significant predictor of success in all the QoL domains except for anxiety or depression (i.e. washing and dressing, with mobility, performing usual activities, or pain and discomfort), with increasing OKS associated with increased odds of having no or slight problems.

These findings are consistent with that of other studies. It has been documented that people who have severe symptoms have poorer functional outcomes and satisfaction after TKR surgery as compared to those who are less advanced in the disease process (Judge et al., 2012; Lim, Luscombe, Jones, & White, 2006; Scott et al., 2010).

It is also reasonable for the result to show that the baseline OKS predicted all the QoL fields except for anxiety and depression as improvements in pain and functional ability are the main indicators for TKR surgery.

When the OKS was categorized into low, medium, and high scores, it was a significant predictor of pain or discomfort, usual activities, and mobility. In each case patients with low scores were less likely to have no or slight problems than those with moderate scores, and the high scores were (not significantly) more likely to have no or slight problems than the medium scores. This demonstrates that a lineal relationship exists which suggests that patients with high OKS do not have poorer outcomes following TKR surgery.

This categorization of OKS into low, medium and high was proposed by Clement et al (2013) as post-operative satisfactions where scores of 0-26, 27-35 and >36 represented that patients are more likely to be dissatisfied, satisfied and very satisfied with the outcomes of TKR respectively. This study utilised the same categories for TKR patients pre-operatively as no other categorical system currently exists. The results of this study indicate that the same categories suggested by Clement et al (2013) can be used pre-operatively in determining the outcomes of surgery particularly in the domains of pain, usual activities and mobility as described by the EQ-5D-5L. Therefore, the OKS maybe a useful measure pre-operatively to monitor patients' symptoms and TKR surgery accelerated as patients' pre-operative OKS are nearing 26 given that six month outcomes decline if their pre-operative OKS is below this mark.

Measures should be established to reduce the likelihood of patients' deterioration in symptoms as reflected in an OKS of <26. Skou et al (2015) found that non-surgical-treatment group which was delivered by a physiotherapist and dietitian comprising of exercise, education, dietary advice, use of insoles, and pain medication had clinically relevant improvements. This improvement was significantly less than that of TKR. This result supports that TKR is the treatment of choice for patients with moderate to severe OA of the knee. However, conservative treatment while patients are on the elective surgical waitlist can prevent deterioration in patients' symptoms and potentially improve six months post-operative outcomes.

The findings of this investigation showed that OKS can be effective in predicting outcomes using a validated QoL patient-reported outcome measure. However, it did not find any associations between the pre-operative OKS and the measure of patient-reported success used in ACORN. A subjective measure of patient-reported success may not be the most sensitive post-operative outcome measure. This study showed that of the 70 patients who had no change or worse OKS post-operatively, 37% of the participants still rated their knee to be at least slightly better six months after surgery. This is supported by Judge et al (2012) who demonstrated that patient-reported satisfaction can be unreliable in determining the outcomes of surgery. Their study showed that of 143 patients who had no change or worse symptoms post-operatively, 78 (54.6%) were still satisfied with the outcomes of the surgery. Future studies may be required to validate patient-reported measures of satisfaction and success following TKR surgery.

Strengths and Limitations

Strengths of this research include the prospectively collected data by Arthroplasty Clinical Outcomes Registry National which reduces selection bias. The data is also collected across multiple sites, which improves the heterogeneity of the data and promotes generalisability of the results.

The overall sample size of 2458 used in this study is considered adequate. The results generated for low and medium OKS categories (OKS 0-35) can be regarded as robust as it included 98% of the dataset. However, the high OKS category only accounted for 2% of the overall dataset. This could be limiting the results where the effect is hypothesised to be due to the lack of data at this high end of the scale.

As the patient records were supplied by a joint registry, it is plausible that non-respondent bias may occur. Patients who did not respond or 'opted out' to the 6 months follow-up may potentially have different results compared to the responders.

Due to the nature of the study design, other possible biases such as recall and response bias may also influence the outcome of the research (Krishna et al., 2010). As the data is collected six months after the TKR surgery, it may be plausible that there could be differences in the accuracy of the experience retrieved by study participants.

Response bias, where the participants aims to be 'good experimental subjects' and provide socially desirable responses may further skew the results of this research. This may be supported by the differences in the response for the cohort of participants with OKS >40 between this study and that of Judge et al (2012). Their study showed that 46% of the participants with OKS >40 were worse. This is a marked difference compared with 0% from the participants of this study. There is possibility that a cultural difference exists between the respondents of these two studies leading to these varied responses.

Conclusion and Recommendations

This study has demonstrated that pre-operative OKS is not a predictor of patient-reported success at six months. In particular, no association was found between high OKS and poor patient-reported success. A significant association was found between pre-operative OKS and all patient-reported EQ-5D-5L QoL domains (mobility, personal care, usual activities, and pain) except "anxiety and depression" six months following TKR surgery.

There is lack of evidence to advise TKR patients of potential patient-reported success by utilising the OKS pre-operatively. There is some evidence that those with lower (<26) OKS have worse outcomes on the EQ-5D-5L domains of pain, usual activities and mobility, compared to those with moderate OKS. Measures (such as physiotherapy and dietetics)

should be established for patients waiting for surgery to minimise deterioration in symptoms.

People having TKR surgery may consider surgery prior to deterioration of symptoms below an OKS of <26.

Further study is needed to evaluate outcomes of TKR patients with high OKS. Studies with a larger sample size of patients with OKS >40 is recommended to adequately investigate outcomes following surgery in this cohort. This will provide more robust results on the suitability of operating on TKR patients with minimal pain and functional disability pre-operative as indicated by the OKS.

Future studies are recommended to validate the results of this research. In particular, the result of inferior post-operative results associated with pre-operative OKS <26 was based on categorical system developed by Clement et al (2013). Future analysis should be performed to determine if OKS <26 is the most significant point in the OKS associated with inferior six months post-operative results.

In addition, further research is required to investigate the validity of patient-reported measures of success and satisfaction for patients following TKR surgery utilised by ACORN.

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Appendix 1

Table 7: Possible predictors by Success at 6 months - 'much better' cut point

Variable	Not Successful (N=470)	Successful (N=1772)	P-Value
Primary diagnosis			
Osteoarthritis	444 (98%)	1691 (98%)	0.84
Osteonecrosis/Other inflammation/Rheumatoid arthritis/Other	9 (2.0%)	37 (2.1%)	
Missing	17	44	0.34
Total joint replacement – any			
No	311 (71%)	1155 (69%)	0.64
Yes	130 (29%)	512 (31%)	
Missing	29	105	
Knee replacement, previous			
No	18 (14%)	68 (13%)	0.78
Yes	107 (86%)	438 (87%)	
Missing	345	1266	
Hip replacement, previous			
No	94 (76%)	371 (78%)	0.66
Yes	29 (24%)	103 (22%)	
Missing	347	1298	
Anaesthetic score			
1. a normal healthy person	16 (4.3%)	77 (5.5%)	0.86*
2. a person with mild systemic disease	219 (59%)	816 (59%)	
3. a person with severe systemic disease	134 (36%)	487 (35%)	
4. a person with severe systemic disease that is a	3 (0.8%)	11 (0.8%)	
5. a moribund oerson who is not expected to survive		1 (0.1%)	
Missing	98	380	
Gender			
Female	308 (66%)	1128 (64%)	0.45
Male	162 (34%)	644 (36%)	
Missing	0	0	
Admission to high dependency unit			
No	434 (93%)	1609 (92%)	0.22
Yes	31 (6.7%)	148 (8.4%)	
Missing	5	15	
Planned high dependency unit			
No	12 (40%)	40 (28%)	0.20
Yes	18 (60%)	102 (72%)	
Missing	440	1630	
Blood transfusion			
No	439 (94%)	1637 (93%)	0.68
Yes	29 (6.2%)	118 (6.7%)	
Missing	2	17	
Admission complication			
No	382 (83%)	1484 (85%)	0.17
Yes	81 (17%)	259 (15%)	
Missing	6	29	
Admission complication number			
1	71 (88%)	221 (86%)	0.94
2	9 (11%)	31 (12%)	
3	1 (1.2%)	4 (1.6%)	
5		1 (0.4%)	
Missing	389	1515	
Discharge destination			
Another acute care hospital	4 (0.9%)	2 (0.1%)	0.01
Inpatient rehabilitation another hospital	35 (7.6%)	113 (6.5%)	
Inpatient rehabilitation same hospital	71 (15%)	226 (13%)	
Other	2 (0.4%)	2 (0.1%)	
Usual residence or residence of relative/friend	347 (76%)	1406 (80%)	

Variable	Not Successful (N=470)	Successful (N=1772)	P-Value
Missing	11	23	
Expectation of pain pre-op			
Moderate pain	24 (6.3%)	93 (6.2%)	0.97
No pain	238 (62%)	917 (61 %)	
Severe pain	2 (0.5%)	9 (0.6%)	
Slight pain	117 (31%)	476 (32%)	
Missing	89	277	
Expectation of function pre-op			
Moderate limitation	25 (6.5%)	89 (6.0%)	0.61
No limitation	218 57%)	826 (55%)	
Severe limitation	1 (0.3%)	1 (0.1%)	
Slight limitation	139 (36%)	577 (39%)	
Missing	87	279	
Comorbid lower back pain			
Yes	162 (37%)	495 (30%)	0.01
No	275 (63%)	1138 (70%)	
Missing	33	139	
Comorbid arthritis			
Yes	131 (30%)	439 (27%)	0.23
No	307 (70%)	1186 (73%)	
Missing	32	147	
Comorbid heart disease			
Yes	173 (39%)	548 (33%)	0.02
No	269 (61%)	1111 (67%)	
Missing	28	113	
Comorbid high blood pressure			
Yes	296 (68%)	1070 (65%)	0.25
No	140 (32%)	577 (35%)	
Missing	34	125	
Comorbid diabetes			
Yes	131 (29%)	412 (24%)	0.04
No	320 (71%)	1276 (76%)	
Missing	19	84	
Comorbid stomach disease			
Yes	124 (27%)	393 (23%)	0.07
No	327 (73%)	1293 (77%)	
Missing	19	86	
Comorbid lung disease			
Yes	102 (23%)	299 (18%)	0.02
No	347 (77%)	1388 (82%)	
Missing	21	85	
Comorbid renal failure			
Yes	31 (6.9%)	98 (5.8%)	0.40
No	419 (93%)	1587 (94%)	
Missing	20	87	
Comorbid liver disease			0.72
Yes	12 (2.7%)	40 (2.4%)	
No	439 (97%)	1647 (98%)	
Missing	19	85	
Comorbid neurological condition			
Yes	23 (5.1%)	101 (6.0%)	0.47
No	428 (95%)	1585 (94%)	
Missing	19	86	
Comorbid depression			
Yes	85 (19%)	280 (17%)	0.23
No	353 (81%)	1371 (83%)	
Missing	32	121	
Categorised OKS			
Low	358 (83%)	1329 (83%)	0.46
Medium	65 (15%)	228 (14%)	

Variable	Not Successful (N=470)	Successful (N=1772)	P-Value
High	7 (1.6%)	42 (2.6%)	
Missing	40	173	
Highest education level obtained			
<= year 10	253 (63%)	940 (60%)	0.49
year 11-12	27 (6.7%)	108 (6.9%)	
Trade/diploma	110 (27%)	433 (28%)	
Higher education	13 (3.2%)	77 (4.9%)	
Missing	67	214	
Q1 EQ5D personal care			
Moderate problems with washing/dressing	123 (28%)	409 (25%)	0.15
No problems with washing/dressing	153 (35%)	674 (42%)	
Severe problems with washing/dressing	41 (9.4%)	139 (8.6%)	
Slight problems with washing/dressing	113 (26%)	376 (23%)	
Unable to do washing/dressing	4 (0.9%)	0 (0.6%)	
Missing	36	165	
Q1 EQ5D usual activities			
Moderate problems doing usual activities	173 (40%)	651 (40%)	0.93
No problems doing usual activities	27 (6.2%)	117 (7.3%)	
Severe problems doing usual activities	119 (27%)	429 (27%)	
Slight problems doing usual activities	91 (21%)	327 (20%)	
Unable to do usual activities	25 (5.7%)	85 (5.3%)	
Missing	35	163	
Q1 EQ5D discomfort			
Extreme pain or discomfort	43 (9.9%)	153 (9.5%)	0.63
Moderate pain or discomfort	174 (40%)	673 (42%)	
No pain or discomfort	7 (1.6%)	22 (1.4%)	
Severe pain or discomfort	159 (37%)	609 (38%)	
Slight pain or discomfort	52 (12%)	154 (9.6%)	
Missing	35	161	
Q1 EQ5D anxiety			
Extremely anxious/depressed	14 (3.2%)	52 (3.2%)	0.04
Moderately anxious/depressed	107 (25%)	333 (21%)	
Not anxious/depressed	143 (33%)	655 (41%)	
Severely anxious/depressed	45 (10%)	130 (8.1%)	
Slightly anxious/depressed	123 (28%)	441 (27%)	
Missing	38	161	
Q1 EQ5D mobility			
Moderate problems with walking around	188 (43%)	691 (43%)	0.71
No problems with walking around	25 (5.8%)	70 (4.4%)	
Severe problems with walking around	148 (34%)	571 (35%)	
Slight problems with walking around	66 (15%)	257 (16%)	
Unable to walk around	7 (1.6%)	20 (1.2%)	
Missing	36	163	
Age (N=2237)	68.18 (9.50)	69.27 (9.00)	0.02
Continuous OKS (N=2029)	18.5 (8.09)	18.5 (8.15)	0.91
Number of comorbid conditions (N=2242)	2.7 (1.68)	2.36 (1.57)	<0.01
BMI (N=2130)	33.2 (6.42)	33 (6.78)	0.65

*Fisher's exact test

Table 8: Possible predictors by Success at 6 months - 'a little better' cut point

Variable	Not Successful (N=175)	Successful (N=2067)	P-Value
Primary diagnosis			
Osteoarthritis	163 (98%)	1972 (98%)	0.79
Osteonecrosis/Other inflammation/Rheumatoid arthritis/Other	4 (2.4%)	42 (2.1%)	
Missing	8	53	
Total joint replacement – any			
No	121 (72%)	1345 (69%)	0.47
Yes	47 (28%)	595 (31%)	
Missing	7	127	
Knee replacement, previous			

No	8 (18%)	78 (13%)	0.36
Yes	36 (82%)	509 (87%)	
Missing	131	1480	
Hip replacement, previous			
No	33 (75%)	432 (78%)	0.63
Yes	11 (25%)	121 (22%)	
Missing	131	1514	
Anaesthetic score			
6. a normal healthy person	5 (3.7%)	88 (5.4%)	0.57*
7. a person with mild systemic disease	74 (55%)	961 (59%)	
8. a person with severe systemic disease	54 (40%)	567 (35%)	
9. a person with severe systemic disease that is a	1 (0.7%)	13 (0.8%)	
10. a moribund oerson who is not expected to survive		1 (0.1%)	
Missing	41	437	
Gender			
Female	118 (67%)	1318 (64%)	0.33
Male	57 (33%)	749 (36%)	
Missing	0	0	
Admission to high dependency unit			
No	160 (92%)	1883 (92%)	1.00
Yes	14 (8.0%)	165 (8.1%)	
Missing	1	19	
Planned high dependency unit			
No	7 (54%)	45 (28%)	0.05
Yes	6 (46%)	114 (72%)	
Missing	162	1908	
Blood transfusion			
No	159 (91%)	1917 (94%)	0.16
Yes	16 (9.1%)	131 (6.4%)	
Missing	0	19	
Admission complication			
No	140 (81%)	1727 (85%)	0.16
Yes	33 (19%)	307 (15%)	
Missing	2	33	
Admission complication number			
1	28 (85%)	264 (87%)	0.87
2	4 (12%)	36 (12%)	
3	1 (3.0%)	4 (1.3%)	
5		1 (0.3%)	
Missing	142	1762	
Discharge destination			
Another acute care hospital	2 (1.2%)	4 (0.2%)	0.01
Inpatient rehabilitation another hospital	17 (10%)	131 (6.4%)	
Inpatient rehabilitation same hospital	30 (18%)	267 (13%)	
Other		4 (0.2%)	
Usual residence or residence of relative/friend	119 (71%)	1634 (80%)	
Missing	7	27	
Expectation of pain pre-op			
Moderate pain	13 (9.0%)	104 (6.0%)	0.39
No pain	88 (61%)	1067 (62%)	
Severe pain		11 (0.6%)	
Slight pain	43 (30%)	550 (32%)	
Missing	31	335	
Expectation of function pre-op			
Moderate limitation	12 (8.3%)	102 (5.9%)	0.08
No limitation	81 (56%)	963 (56%)	
Severe limitation	1 (0.7%)	1 (0.1%)	
Slight limitation	50 (35%)	666 (38%)	
Missing	31	335	
Comorbid lower back pain			
Yes	67 (40%)	590 (31%)	0.01

No	99 (60%)	1314 (69%)	
Missing	9	163	
Comorbid arthritis			
Yes	51 (31%)	519 (27%)	0.38
No	116 (69%)	1377 (73%)	
Missing	8	171	
Comorbid heart disease			
Yes	63 (37%)	658 (34%)	0.43
No	107 (63%)	1273 (66%)	
Missing	5	136	
Comorbid high blood pressure			
Yes	113 (68%)	1253 (65%)	0.48
No	53 (32%)	664 (35%)	
Missing	9	150	
Comorbid diabetes			
Yes	44 (26%)	499 (25%)	0.91
No	127 (74%)	1469 (75%)	
Missing	4	99	
Comorbid stomach disease			
Yes	49 (28%)	468 (24%)	0.17
No	123 (72%)	1497 (76%)	
Missing	3	102	
Comorbid lung disease			
Yes	44 (26%)	357 (18%)	0.01
No	126 (74%)	1609 (82%)	
Missing	5	101	
Comorbid renal failure			
Yes	17 (9.9%)	112 (5.7%)	0.03
No	154 (90%)	1852 (94%)	
Missing	4	103	
Comorbid liver disease			
Yes	6 (3.5%)	46 (2.3%)	0.35
No	166 (97%)	1920 (98%)	
Missing	3	101	
Comorbid neurological condition			
Yes	11 (6.4%)	113 (5.8%)	0.73
No	161 (94%)	1852 (94%)	
Missing	3	102	
Comorbid depression			
Yes	39 (23%)	326 (17%)	0.04
No	128 (77%)	1596 (83%)	
Missing	8	145	
Categorised OKS			
Low	135 (83%)	1552 (83%)	1.00
Medium	24 (15%)	269 (14%)	
High	4 (2.5%)	45 (2.4%)	
Missing	12	201	
Highest education level obtained			
<= year 10	100 (65%)	1093 (60%)	0.29
year 11-12	8 (5.2%)	127 (7.0%)	
Trade/diploma	42 (27%)	501 (28%)	
Higher education	3 (2.0%)	87 (4.8%)	
Missing	22	259	
Age (N=2237)	68.14 (10.38)	69.12 (9.00)	0.18
Continuous OKS (N=2029)	18.6 (8.33)	18.5 (8.12)	0.88
Number of comorbid conditions (N=2242)	2.88 (1.79)	2.39 (1.58)	<0.01
BMI (N=2130)	33.5 (6.68)	33 (6.70)	0.40

*Fisher's exact test

APPENDIX 2

Oxford Knee Score

Oxford Knee Score (OKS)

English version for the United Kingdom

Prior to completing the questionnaire please complete the following:-

Today's Date:

D D M M 2 0 Y Y Y Y

On which side of your body is the affected knee **for which you are receiving treatment**?

Left ❑
Right ❑
Both ❑

If you said 'both', please complete the first questionnaire thinking about the right side. A second questionnaire, for the left side, will follow.

PROBLEMS WITH YOUR KNEE

Tick (✓) one box for every question.

1. During the past 4 weeks...

How would you describe the pain you usually have from your knee?

None	Very mild	Mild	Moderate	Severe
☐	☐	☐	☐	☐

2. During the past 4 weeks...

Have you had any trouble with washing and drying yourself (all over) because of your knee?

No trouble at all	Very little trouble	Moderate trouble	Extreme difficulty	Impossible to do
☐	☐	☐	☐	☐

3. During the past 4 weeks...

Have you had any trouble getting in and out of a car or using public transport because of your knee? (whichever you tend to use)

No trouble at all	Very little trouble	Moderate trouble	Extreme difficulty	Impossible to do
☐	☐	☐	☐	☐

4. During the past 4 weeks...

For how long have you been able to walk before pain from your knee becomes **severe**? (with or without a stick)

No pain/More than 30 minutes	16 to 30 minutes	5 to 15 minutes	Around the house only	Not at all/pain severe when walking
☐	☐	☐	☐	☐

5. During the past 4 weeks...

After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee?

Not at all painful	Slightly painful	Moderately painful	Very painful	Unbearable
☐	☐	☐	☐	☐

6. During the past 4 weeks...

Have you been limping when walking, because of your knee?

Rarely/ never	Sometimes, or just at first	Often, not just at first	Most of the time	All of the time
☐	☐	☐	☐	☐

7. During the past 4 weeks...

Could you kneel down and get up again afterwards?

Yes, easily	With little difficulty	With moderate difficulty	With extreme difficulty	No, impossible
☐	☐	☐	☐	☐

8. During the past 4 weeks...

Have you been troubled by pain from your knee in bed at night?

No nights	Only 1 or 2 nights	Some nights	Most nights	Every night
☐	☐	☐	☐	☐

9. During the past 4 weeks...

How much has pain from your knee interfered with your usual work (including housework)?

Not at all	A little bit	Moderately	Greatly	Totally
☐	☐	☐	☐	☐

10. During the past 4 weeks...

Have you felt that your knee might suddenly 'give way' or let you down?

Rarely/ never	Sometimes, or just at first	Often, not just at first	Most of the time	All of the time
☐	☐	☐	☐	☐

11. During the past 4 weeks...

Could you do the household shopping on your own?

Yes, easily	With little difficulty	With moderate difficulty	With extreme difficulty	No, impossible
☐	☐	☐	☐	☐

12. During the past 4 weeks...

Could you walk down one flight of stairs?

Yes, easily	With little difficulty	With moderate difficulty	With extreme difficulty	No, impossible
☐	☐	☐	☐	☐

Finally, please check back that you have answered each question.

Thank you very much.

APPENDIX 3

EQ-5D-5L

EQ-5D-5L

Health Questionnaire

English version for the UK

Under each heading, please tick the ONE box that best describes your health TODAY.

MOBILITY

- I have no problems in walking about ❑
- I have slight problems in walking about ❑
- I have moderate problems in walking about ❑
- I have severe problems in walking about ❑
- I am unable to walk about ❑

SELF-CARE

- I have no problems washing or dressing myself ❑
- I have slight problems washing or dressing myself ❑
- I have moderate problems washing or dressing myself ❑
- I have severe problems washing or dressing myself ❑
- I am unable to wash or dress myself ❑

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

- I have no problems doing my usual activities ❑
- I have slight problems doing my usual activities ❑
- I have moderate problems doing my usual activities ❑
- I have severe problems doing my usual activities ❑
- I am unable to do my usual activities ❑

PAIN / DISCOMFORT

- I have no pain or discomfort ❑
- I have slight pain or discomfort ❑
- I have moderate pain or discomfort ❑
- I have severe pain or discomfort ❑
- I have extreme pain or discomfort ❑

ANXIETY / DEPRESSION

- I am not anxious or depressed ❑
- I am slightly anxious or depressed ❑
- I am moderately anxious or depressed ❑
- I am severely anxious or depressed ❑
- I am extremely anxious or depressed ❑

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.

YOUR HEALTH TODAY = ☐