Patients follow three distinct outcome trajectories following total knee arthroplasty

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ABSTRACT

Introduction

Total Knee Arthroplasty is a highly successful procedure though typically 20% of patients are reported as being dissatisfied. This proportion is derived from dichotomous models of surgical success or failure, which may not well reflect the spectrum of clinical outcomes. This study explores differing responses to surgery and evaluates whether there are distinct patient groups in relation to different patterns of outcome.

Methodology

This was a secondary analysis of a UK multi-centre TKA longitudinal cohort study. We employed a group-based trajectory modelling analysis of Oxford Knee Score (OKS) in the first year following surgery using longitudinal data consisting 5-different time points and multiple predictor variables. Associations between the derived trajectory groups and categorical baseline variables were assessed and predictors of trajectory group membership identified using *Poisson* regression and multinomial logistic regression as appropriate. The final model was adjusted for socio-demographic factors (age, sex) and baseline OKS.

Results

Data from 731 patients were available for analysis. Three distinct trajectories were identified: "poor" 14.0%, "modest" 39.1%, and "good" 46.9%. The predicted probability of membership for individuals assigned to each trajectory group was high (0.89-0.93). Pre-operative mental, physical health and psychosocial factors determined which trajectory is likely to be followed. Poor responders were characterised by a comparatively small number of factors, pre-operative expectations of pain and limitations, coping strategies, and a lower baseline physical health status, while the good responders were characterised by a combination of clinical, psychosocial, mental health and quality of life factors.

Conclusion

Three distinct response trajectories in patients undergoing TKA. Controlling for baseline score, age and gender, psychosocial factors such as expectations of pain and limited function and poor coping strategies differentiated patients trajectory groups, suggesting a role for pre-operative psychosocial support in elevating clinical outcomes post-operatively.

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most common and cost-effective treatments for severe knee osteoarthritis[1], with >100 000 knee replacements performed in the UK annually[2]. Though generally a very successful procedure in improving the pain and limited function of knee osteoarthritis, not all patients benefit from surgery and there is great interest in predicting those at risk of poor outcomes following TKA, to optimise patient outcomes, counsel patients as to likely outcomes, target resources and minimise costs[3].

It is typically reported that 80% of patients are satisfied with the outcomes of surgery, or the correlate, that 20% are dissatisfied. As such we tend to think about dichotomous 'good and bad' clinical outcomes of knee arthroplasty. Satisfaction is a useful overarching metric to highlight the patient's perception of outcomes[4], but is a somewhat crude indicator of success when delineated in this binary way and masks large variations in clinical outcomes[5,6]. Few patients or clinicians would agree with a black and white determination as to the success of surgery.

Various patient characteristics and symptom severity markers have been associated with arthroplasty outcomes. Notably, pre-operative pain and function, and demographic factors are thought to influence TKA outcomes. Though this relationship is typically derived with rigorous area-under-the-curve based statistics, these values are inherently based on the premise of dichotomous good or bad outcomes, which perhaps does not fully reflect the more nuanced clinical picture. The importance of psychosocial factors is also increasingly recognized. The relationship between psychosocial factors and TKA outcomes has been examined in several systematic reviews[7,8], which have consistently indicated poor preoperative mental health and pain catastrophizing to be strongly associated with greater postoperative pain and functional disability. Again though, these associations tend to describe the relationship of variables with a global marker of success or failure.

The purpose of this study is to explore improvement in patient outcomes following total knee arthroplasty to determine differing responses to surgery and to evaluate whether there are distinct patient groups in relation to different patterns of outcome.

METHODS

Study design

This was a secondary analysis of an existing dataset. Data was extracted from the TRIO-POPULAR dataset[9]. This was a multi-centre, prospective cohort study of 971 patients undergoing primary TKA for osteoarthritis from 9 participating centres across the UK. The potential of a large number of variables to predict outcome was assessed (defined below) and all were available for modelling in this analysis. Participants were evaluated pre-operatively and then at 6-weeks, 3, 6, and 12-months following surgery. The study was approved by the Office for Research Ethics Committees Northern Ireland (13/NI/0101).

Outcome Measurements

Sociodemographic factors:

Socio-demographic data including age, gender, marital status, and highest education level (a proxy for socioeconomic status) were determined preoperatively.

Clinical factors:

Clinical factors included duration of knee pain, self-reported comorbidities, the Chronic Pain Grade (CPG), and sleep disturbance. The CPG contains 7-items which allow respondents to be classified into five categories: Grade 0 (no pain), Grade I (low disability/low intensity), Grade II (low disability/high intensity), Grade III (high disability/moderately limiting intensity), and Grade IV (high disability and highly limiting disability)[10]. Severe sleep disturbance measured by the 4-item Sleep Problem Scale was defined as a mean score ≥ 4, corresponding to at least 15 troubled nights per month[11].

Psychosocial factors:

The Illness Attitude Scales (IAS) measures personal attitudes, fears, and beliefs associated with hypochondriasis and abnormal illness behaviour[12,13]. It consists of nine subscales, each with three items on a 0-4 Likert scale. A higher score represents greater hypochondriacal fears and beliefs. Among participants who reported they had aches or pains lasting one day or longer in the past month, the Vanderbilt Pain Management Inventory was used to assess chronic pain coping strategies[14]. This questionnaire consists of 18-items, rated on a 5-point frequency Likert scale that produces two subscales; active coping score and passive coping score. High scores indicate a high use of active and passive coping strategies respectively. Patient expectations of pain, and limitations in everyday activities after TKA were also measured using visual analogue scales (VAS); 0 representing ‘not at all painful’ or ‘not limited at all’ and 100 ‘very painful’ or ‘greatly limited’, respectively[15].

Mental and Physical Health:

The Hospital Anxiety and Depression Scale (HADS)[16] and the Patient Reported Outcome Measurement System 10 (PROMIS-10) Global Health Questionnaire[17] was used to evaluate mental and physical health. The HADS is a 14-item questionnaire; seven items measuring anxiety and seven items measuring depression. Each item is rated on a 0-3 Likert scale with higher scores indicating poorer mental health. The PROMIS-10 Questionnaire has 10-items to generate the Global Physical Health and Global Mental Health sub-scales. Scores range from 4 to 20 with higher scores indicating better health.

Quality of life:

The EuroQoL 5-dimension 3L version (EQ-5D-3L) was used to measure quality of life[18]. It consists of five dimensions; mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, rated on a 3-point scale. Each EQ-5D profile was converted to a single summary index based on the valuation of health states in the UK. A score of 1.0 indicates the best possible health.

Pain and function:

The Oxford Knee Score (OKS) measures the impact of pain and functional disability in patients undergoing knee replacement[19]. The scoring system ranges from 0 to 48 with higher scores representing more favourable outcomes.

Statistical analysis

Descriptive statistics were used to report patient demographic, clinical, and health-related quality of life characteristics of the sample population. For normally distributed continuous variables, means and standard deviations (SD) were calculated; counts and proportions were calculated for categorical variables.

Group-based trajectory modelling was applied to identify subgroups of patients with distinct trajectories based on their OKS scores (pain and function). OKS scores were plotted from the time of diagnosis to 12 months post-surgery. Patients with only single time point measurements were not eligible for this evaluation to maintain the longitudinal aspect of the analysis. The selection of the model was based on standard group-based modelling assumption[20]. Statistical criteria; Akaike's Information Criterion (AIC) and Bayesian information Criterion (BIC), were used to ascertain the best-fitting model[21,22]. Lower values of AIC and BIC indicate better model fit. To further evaluate the adequacy of the selected models, the following diagnostics were carried out: (1) the average posterior probabilities of membership for individuals assigned to each trajectory group (>0.7), (2) the odds of correct classification (>5), and (3) the observed classification proportion *vs.* the expected classification proportion on the basis of the posterior probability of group membership[20]. Other criteria included non-overlapping, narrow confidence intervals and adequate sample sizes in each identified trajectory group (<5%). Our aim was to select a parsimonious model that best described simple and distinctive trajectories based on these indices while considering clinical usefulness.

Associations between the derived trajectory groups and categorical baseline variables were assessed using chi-square tests. The Kruskal-Wallis test or analysis of variance (ANOVA) was used to test the differences within trajectory groups for non-normal and normally distributed continuous variables, respectively. *P* values < 0.05 were considered to be statistically significant throughout the analyses.

Predictors of trajectory group membership were identified using *Poisson* regression for outcomes with two trajectory groups and multinomial logistic regression for outcomes with more than two trajectory groups. Model variable entry was based on a univariate p<0.15 to control for collinearity of variables. The final model was adjusted for socio-demographic factors (age, sex) and baseline OKS. These adjustments were made as these variables have previously been shown to be associated with variations in pain perceptions and physical functioning[9]. All analyses were completed using STATA version 14.0 (StataCorp, 2015).

RESULTS

The underlying study dataset comprised n=971 individuals who provided data at baseline. Follow-up data was available for n=781 at 6-weeks, n=745 at 3-months, n=715 at 6-months, and n=695 at 12-

months. Within this dataset, n=731 individuals provided a minimum of 2 linked timepoint responses and were included in this analysis. The median age of the participants was 69 years, 53% were female, and approximately half reported education beyond secondary-school level (Table 1). The average duration of symptoms was approximately 7 years (interquartile range (IQR) 2, 10) and baseline OKS was 21 (IQR 15, 26). Most participants were retired (56.5%), though approximately one in four reported they were still working either full time or part time.

Group based trajectory model selection

Various two- to five-group models were generated for response trajectory. There was a continuous decrease in the AIC and BIC from the two- to four-group models with minimal difference between the three- and four-group models. However, the four-group and the five- group models gave rise to one or more groups with a very small proportion of the observations. In the interest of parsimony, we chose the model with fewer classes (supplemental data table). Our results indicated that a three-group model with a quadratic slope was the best fit to the data (BIC=-12400; AIC=-12372).

We classified the 3 score change trajectory groups as "poor responder" 14.0%, "modest responder" 39.1%, and "good responder" 46.9% (Figure 1). The predicted probability of membership for individuals assigned to each trajectory group were high (0.89-0.93). All three trajectory groups followed a similar pattern of longitudinal change with varying degree of improvements in their pain and function. This suggests similar temporal trends in recovery. Steady improvements can be observed in the first 3 months followed by a general plateau beyond 6 months.

Patient characteristics by Trajectory Group

The descriptive (pre-operative) characteristics of the patients that comprise the three different responder groups is presented in Table 2. Significantly higher proportions of female patients who underwent TKA were found in the poor- (59%) and modest-responder (61%) groups compared to the good responders (44%). The poor- and modest-responder groups had the highest prevalence of chronic widespread pain and severely limiting disability. These groups also had the highest proportion of severe sleep disturbances reported (28% and 18%, respectively) compared to the good responders (9%). The good responder group had significantly better pain and functional outcomes preoperatively compared to the other two groups. This group also corresponded with better mental and physical health and perceived quality of life (EQ5D) (Table 2).

Predictors of Trajectory Group Membership

The unadjusted associations between the individual preoperative variables and group membership is presented in Table 3 where the 'modest' responder group is taken as the base comparator with which the 'poor' and 'good' responder groups are contrasted. Chronic widespread pain, sleep disturbance, larger number of comorbidities, depression (HADS questionnaire) and baseline quality of life (PROMIS and EQ5D scores) were associated with increased likelihood of classifying as a poor responder in contrast to a modest responder and also the likelihood of classifying as good responder in contrast to a modest responder (Table 3). We derived a predictor model of group membership based on this unadjusted data, contrasting the poor to modest responder and modest to good responder group characteristics, controlling for baseline OKS, age, and sex (Table 4). Poor

responders were characterised by a comparatively small number of factors; pre-operative expectations of pain and limitations, coping strategies and a lower baseline physical health status. In contrast, the differences between modest and good responders were characterised by a combination of clinical, psychosocial, mental health and quality of life factors. In addition to expectation factors, the relative probability of achieving a good outcome (as opposed to modest) is 40-50% lower for those with significant pre-operative pain issues (pain intensity, multiple joint involvement, or sleep disturbance), and those with significant anxiety or depression scores (Table 4).

DISCUSSION

We have identified three distinct response trajectories in Oxford Knee Score following total knee arthroplasty and report the factors that predict membership of these different groups of patients. Pre-operative mental health, physical health and psychosocial factors (including expectations of outcome) broadly determine which trajectory is likely to be followed.

Patients suffering poor post-operative outcomes can be difficult to treat. Regrettably, there is often little that can be done to improve the situation with pharmacologic or therapeutic modalities and progression to revision surgery is not always warranted nor desirable. As such identification pre-TKA as to those patients that may struggle in the post-operative period is desirable to target prophylactic mitigation strategies, which could include targeted physical or mental health optimisation though physiotherapy or behavioural therapies, and inform the consent process.

As opposed to simply dichotomising surgical outcomes as successful or not, we applied a group-based modelling approach which allowed for the possibility of multiple different groups following distinct trajectories of change in OKS. Group-based trajectory modelling is used to describe different patterns of outcome over time and identifies clusters of individuals who follow similar longitudinal patterns[23]. These models are increasingly being applied in clinical research to map the course of symptoms and assess heterogeneity in response to clinical interventions. Where, historically, a hierarchical modelling approach has been used to measure the change in a variable over time and determine the covariates that influence this, group based modelling assumes that the total population is composed of distinct groups with differing underlying trajectories. The parameters of group-based trajectory models are generated by maximum likelihood estimation, identifying these groups and then estimating the influence of covariables on both the trajectory shape and the group membership.

We found the traditionally reported poor response (in 14% of cases), but additionally report distinct modest and good responder profiles within the remaining 85%. Modest and good outcome trajectory groups were similarly proportioned at 39% and 47% of the total study population respectively. The second aspect of group-based modelling is distinguishing the parameters that drive the categorisation into the different groups. Case-mix characteristics correspond to and influence the likelihood of being in each group. As anticipated, pre-operative Oxford Knee Score was strongly associated with the primary outcome (post-operative OKS) and therefore the response trajectory. As such we controlled our final model for this influence alongside patient age and sex to provide an unbiased estimate of the differences between groups. We found that psychosocial factors were key to determining the differing responder groups. These variables dominated the model separating the poor from the modest outcome groups and contributed alongside baseline symptom severity factors to the differences between modest and good responders.

Meints et al.[7] recently reviewed the characteristics of pain in orthopaedic surgery and highlighted that the biopsychosocial model of pain recognizes contributions of biological, psychological, and social modulators of the pain experience. Psychosocial and mental health factors have been increasingly associated with poor clinical outcomes[24-28]. Anxiety and depression have been found to be predictive of low outcome scores and increased complications[29,30]. While pre-operative pain catastrophising has been separately identified as an independent risk factor for chronic pain post-TKA[31]. More generally, pre-operative expectations of outcome are thought to be good predictors clinical[32,33] outcomes and satisfaction[34] following TKA. Sorel et al.[8] investigated the association between preoperative psychological distress and postoperative pain and function following TKA. Through meta-analysis of data from 1525 patients they concluded that preoperative pain catastrophizing, mental distress, symptoms of anxiety and/or depression adversely affect pain and function after TKA. They further suggest that some patients undergoing TKA may benefit from psychological support to improve their post-operative outcome and quality of life. We suggest that it is not just patients that dichotomously report poor outcomes that may benefit from interventions addressing problematic pain beliefs prior to surgery, in our analysis this was also associated with achieving a modest response as opposed to good, perhaps suggesting a wider role for therapies to address health beliefs and anxiety. Those following the 'good' outcome trajectory additionally reported low baseline levels of disease chronicity. The relative probability of achieving a good outcome (as opposed to modest) is 40-50% lower for those with significant pre-operative pain issues (pain intensity, multiple joint involvement, or sleep disturbance), and those with significant anxiety or depression scores. Attitude towards recovery also meaningfully influences the likelihood of responder category – featuring in both poor-modest and modest-good predictor models.

Surgeons will be unsurprised that those patients with expectations of a difficult recovery following surgery and that tend towards passive coping strategies look to achieve something of a self-fulfilling prophecy, while those in reasonable physical health with realistic expectations of outcomes and a positive attitude towards recovery tend to feature in the good outcome responder category. This data however demonstrates that these factors can distinguish between the three distinct OKS outcome trajectories we report following TKA. Of note, 53% of patients did not follow the 'good' outcome trajectory suggesting a substantial role for pre-operative psychosocial support in elevating clinical outcomes post-operatively.

Strengths and limitations

We believe this is the first group-based modelling evaluation to determine response trajectories of OKS following TKA. Strengths of this work include the multiple time point longitudinal data and wide battery of predictor variables we were able to employ for the models, however the relatively restricted number of clinical variables, such as radiographic degree of joint damage or BMI, should be considered as a limitation. We think it is unlikely that these variables would substantially influence our models however as radiographic OA severity is well accepted to be unrelated to symptoms and there is a well-established link between BMI and OKS that would likely be colinear and accommodated within the multivariate analysis. The large multi-centre national sample we used for analysis suggests generalisability, at least in the wider UK setting.

Conclusions

As opposed to dichotomous good and bad outcomes, three distinct outcomes trajectories of the Oxford Knee Score are evident following total knee arthroplasty. Baseline pain and dysfunction in addition to psychosocial and mental health parameters classify which outcome trajectory patients are likely to follow. These findings may be useful in informing surgical decision making and in delivering pre-operative interventions to enhance eventual surgical outcomes.

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TABLES

Table 1. Characteristics of the study population at baseline

			N
Demographic and socioeconomic characteristics			
Age (years; mean, SD)	68.2	8.6	721
No. female (n, %)	379	52.6%	721
Education (n, %)			
Secondary school	356	49.5%	
Apprenticeship	81	11.3%	
Further education college	188	26.2%	
University degree	69	9.6%	
Further degree	25	3.5%	719
Marital status (n, %)			
Single	35	4.9%	
Married or Co-habiting	509	70.9%	
Widowed	100	13.9%	
Divorced or Separated	75	10.4%	719
Clinical factors			
Duration of knee pain (median years, IQR)	5.0	2.0-10.0	699
Baseline Oxford Knee Score (mean, SD)	20.6	7.3	709
No. of comorbidities (n, %)			
≤ 1	175	24.3%	
2-3	421	58.4%	
≥4	125	17.3%	721

Table 2. Descriptive (pre-operative) characteristics for each OKS trajectory subgroup

Characteristics	Trajectory groups			*p*-value[1]
	Poor responder[2]	Modest responder	Good responder	
No., n (%)	101 (14.0)	282 (39.1)	338 (46.9)	-
Sociodemographic factors				
Age, mean (SD)	67.4 (9.2)	68.3 (8.6)	69.2 (8.2)	0.147
Female, n (%)	59 (59.0)	171 (60.9)	149 (43.8)	p<0.001
Clinical factors				
Duration of knee pain, median years (IQR)	6.0 (3.0-10.0)	5.0 (2.0-10.0)	4.0 (2.0-9.0)	0.022
Baseline Oxford Knee Score, mean (SD)	13.9 (6.1)	18.6 (6.1)	24.2 (6.6)	p<0.001
Chronic Pain Grade, n (%)				
No pain – Grade 0	5 (5.8)	37 (14.2)	84 (26.5)	
Low disability and low intensity – Grade I	1 (1.2)	14 (5.4)	40 (12.6)	
Low disability and high intensity – Grade II	8 (9.2)	76 (29.2)	91 (28.7)	
High disability and moderate intensity – Grade III	25 (28.7)	54 (20.8)	66 (20.8)	
High disability and high intensity – Grade IV	87 (55.2)	79 (30.4)	36 (11.4)	p<0.001
Chronic widespread pain, n (%)				
Non-chronic widespread pain	77 (19.4)	242 (87.7)	319 (94.4)	
Chronic widespread pain	20 (20.6)	34 (12.3)	19 (5.6)	p<0.001
Sleep disturbance, n (%)				
Mild-moderate sleep disturbance	71 (72.5)	227 (81.7)	309 (91.4)	
Severe sleep disturbance	27 (27.6)	51 (18.4)	29 (8.6)	p<0.001
No. of comorbidities, n (%)				
≤ 1	13 (13.0)	68 (24.2)	94 (27.7)	
2-3	50 (50.0)	155 (55.2)	216 (63.5)	
≥4	37 (37.0)	58 (20.6)	30 (8.8)	p<0.001

Psychosocial factors				
Illness Attitude Score, median (IQR)	30.0 (24.5-39.0)	28.0 (21.0-38.0)	23.0 (17.0-30.1)	p<0.001
Active coping, mean (SD)	21.0 (5.0)	23.3 (4.2)	24.8 (4.6)	p<0.001
Passive coping, mean (SD)	34.6 (7.4)	31.2 (7.0)	26.7 (7.0)	p<0.001
Expectations of knee pain after recovery, median (IQR)	53.0 (24.0-71.0)	39.0 (12.0-70.0)	26.0 (10.0-59.0)	p<0.001
Expectations of limitations after recovery, median (IQR)	46.5 (22.0-64.0)	29.0 (12.0-54.0)	18.0 (7.0-46.0)	p<0.001
Mental and Physical Health				
Anxiety (HADS[3]), n (%)				
Mild anxiety	79 (79.8)	235 (84.2)	323 (95.0)	
Severe anxiety	20 (20.2)	44 (15.8)	17 (5.0)	p<0.001
Depression (HADS), n (%)				
Mild depression	84 (84.9)	257 (92.1)	333 (97.9)	
Severe depression	15 (15.2)	22 (7.9)	7 (2.1)	p<0.001
PROMIS[4] mental health, mean (SD)	42.4 (5.6)	43.7 (5.4)	45.7 (5.0)	p<0.001
PROMIS physical health, mean (SD)	34.7 (3.5)	36.9 (3.4)	38.7 (3.9)	p<0.001
Quality of life				
EQ5D, median (IQR)	3.2 (0.9-4.2)	3.5 (1.6-4.2)	4.2 (3.5-4.6)	p<0.001

[3] Hospital Anxiety Depression Scale

[4] Patient Reported Outcome Measurement System

Table 3 Unadjusted multinomial associations between individual preoperative variables and group membership

Predictors	Poor responder vs. Modest responder		*P*-value	Good responder vs. Modest responder		*P*-value
	Risk Ratio	95% confidence interval		Risk Ratio	95% confidence interval	
Sociodemographic factors						
Age; per unit years	-0.01	-0.04 – 0.02	0.410	0.01	-0.01 – 0.03	0.182
Female	0.93	0.58 – 1.47	0.745	0.50	0.36 – 0.69	p<0.001
Clinical factors						
Duration of knee pain; per unit years	0.02	-0.01 – 0.05	0.201	-0.004	-0.03 – 0.018	0.706
Baseline Oxford Knee Score; per unit (0-48)	-0.13	-0.18 – -0.09	p<0.001	0.13	0.11 – 0.16	p<0.001
Chronic Pain Grade						
No pain – Grade 0	Reference category					
Low disability and low intensity – Grade I	0.53	0.06 – 4.93	0.576	1.26	0.61 – 2.59	0.532
Low disability and high intensity – Grade II	0.78	0.24 – 2.55	0.679	0.53	0.32 – 0.86	0.011
High disability and moderate intensity – Grade III	3.43	1.20 – 9.76	0.021	0.54	0.32 – 0.91	0.022
High disability and high intensity – Grade IV	4.50	1.65 – 12.23	0.003	0.20	0.12 – 0.35	p<0.001
Chronic widespread pain	1.85	1.01 – 3.40	0.048	0.42	0.24 – 0.76	0.004
Severe sleep disturbance	1.69	0.99 – 2.90	0.055	0.42	0.26 – 0.68	p<0.001
No. of comorbidities						
≤ 1	Reference category					
2-3	1.69	0.86 – 3.31	0.128	1.01	0.69 – 1.47	0.966
≥4	3.34	1.62 – 6.87	0.001	0.37	0.22 – 0.64	p<0.001

Psychosocial factors						
Illness Attitude Score; per unit (0-108)	0.01	-0.004 – 0.03	0.126	-0.05	-0.07 – -0.03	p<0.001
Active coping; per unit (7-35)	-0.11	-0.16 – -0.05	p<0.001	0.08	0.03 – 0.12	p<0.001
Passive coping; per unit (11-55)	0.07	0.03 – 0.10	p<0.001	-0.09	-0.12 – -0.06	p<0.001
Expectations of knee pain after recovery; per unit (0-100)	0.001	0.0005 – 0.02	0.038	-0.01	-0.01 – -0.002	0.010
Expectations of limitations after recovery; per unit (0-100)	0.01	0.003 – 0.02	0.011	-0.01	-0.02 – -0.01	p<0.001
Mental and Physical Health						
Severe anxiety (HADS[5])	1.35	0.75 – 2.43	0.314	0.28	0.16 – 0.50	p<0.001
Severe depression (HADS)	2.09	1.03 – 4.20	0.040	0.25	0.10 – 0.58	0.001
PROMIS[6] mental health; per unit (4-20)	-0.05	-0.09 – -0.004	0.033	0.07	0.04 – 0.10	p<0.001
PROMIS physical health; per unit (4-20)	-0.18	-0.24 – -0.11	p<0.001	0.14	0.09 – 0.18	p<0.001
Quality of life						
EQ5D, per tenth of a unit (-0.5-1.0)	-0.20	-0.33 – -0.07	0.003	0.47	0.34 – 0.60	p<0.001

[5] Hospital Anxiety Depression Scale

[6] Patient Reported Outcome Measurement System

Table 4. Predictors of group membership adjusted for age, sex, and baseline OKS

Predictors	Poor responder vs. Modest responder†		*P*-value	Good responder vs. Modest responder†		*P*-value
	Risk Ratio	95% confidence interval		Risk Ratio	95% confidence interval	
Clinical factors						
Severe Chronic Pain Grade – *Grade IV*				0.51	0.27 – 0.96	0.037
Chronic widespread pain				0.55	0.29 – 1.04	0.065
Severe sleep disturbance				0.60	0.35 – 1.03	0.064
Psychosocial factors						
Illness Attitude Score; per unit (0-108)				-0.04	-0.06 – -0.02	p<0.001
Active coping; per unit (7-35)	-0.07	-0.13 – -0.01	0.025	0.06	0.02 – 0.11	0.009
Passive coping; per unit (11-55)				-0.04	-0.08 – -0.01	0.015
Expectations of knee pain after recovery; per unit (0-100)	0.01	-0.002 – 0.01	0.119	-0.01	-0.01 – -0.002	0.014
Expectations of limitations after recovery; per unit (0-100)	0.01	0.0002 – 0.02	0.046	-0.01	-0.02 – -0.005	0.001
Mental and Physical Health						
Severe anxiety (HADS[7])				0.47	0.25 – 0.90	0.022
Severe depression (HADS)				0.45	0.18 – 1.16	0.099
PROMIS[8] mental health; per unit (4-20)				0.05	0.02 – 0.09	0.002
PROMIS physical health; per unit (4-20)	-0.08	-0.16 – -0.001	0.048			
Quality of life						
EQ5D, per tenth of a unit (-0.5-1.0)				0.23	0.08 – 0.38	0.004

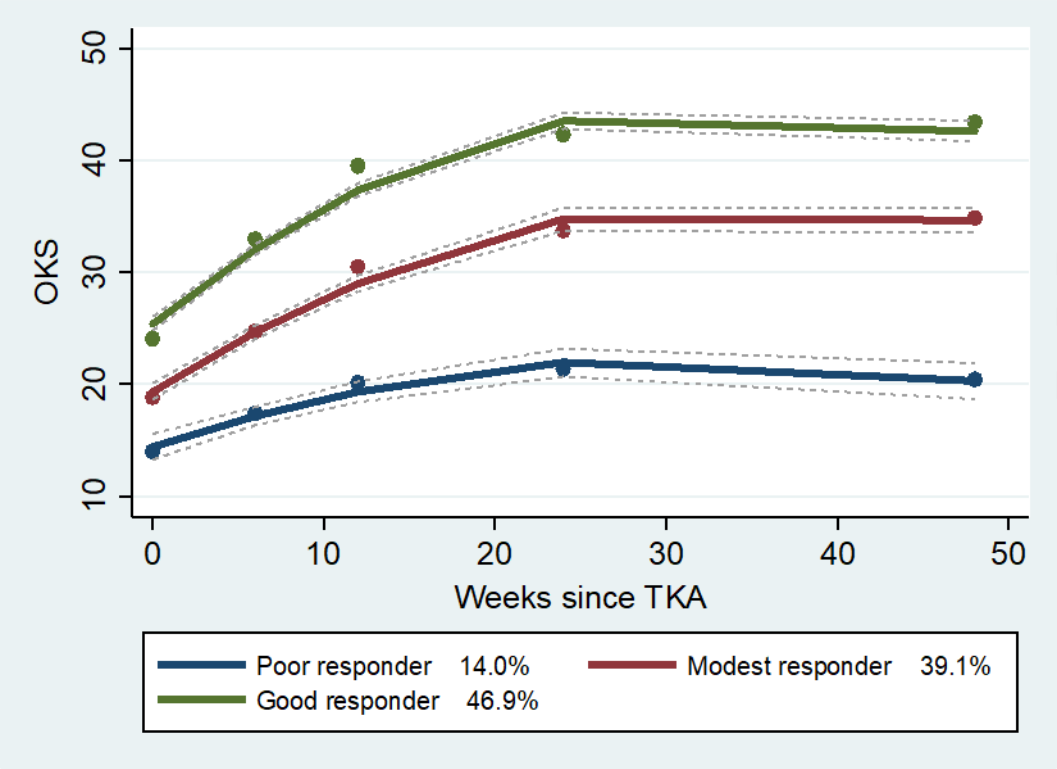
† reference category

[7] Hospital Anxiety Depression Scale

[8] Patient Reported Outcome Measurement System

FIGURES

Figure 1. Trajectories of OKS from baseline to 12 months post TKA



Supplemental data

Supplementary Table. AIC and BIC values based on the number of groups and trajectory shapes

Number of groups	Trajectory shapes[1]	BIC	AIC
2	00	-13767	-13757
2	11	-13044	-13030
2	22	-12588	-12569
3	000	-13755	-13741
3	111	-12952	-12931
3	222	-12400	-12372
4	0000*	-13761	-13742
4	1111*	-12957	-12929
4	2222	-12359	-12321
5	00000*	-13768.	-13745

BIC- Bayesian Information Criterion; the BIC penalises free parameters and balance model fit with model complexity (i.e. favours parsimony). The closer the negative BIC value is to zero, the better is the fit of the model (Schwartz, 1978).

AIC- Akaike Information Criterion

1 Trajectory shapes; 0 = zero-order, 1 = linear, 2 = quadratic

* One or more of the groups had a very small proportion of the observations.