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Association between pre-operative anxiety and/or depression and outcomes following total hip or knee arthroplasty

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Abstract

Purpose: While elective primary total hip (THA) and knee (TKA) arthroplasty are effective procedures for addressing the symptoms associated with advanced osteoarthritis, there is evidence to suggest that patient anxiety and depression are linked to poorer outcomes following surgery. **Methods:** A secondary analysis of prospectively-collected data of people undergoing primary elective THA or TKA for osteoarthritis across 19 hospitals was performed. We assessed outcomes at 1 year post-surgery for people with and without medically treated anxiety and/or depression at the time of surgery (A/D and no-A/D). We used unadjusted and adjusted analyses to compare improvement in Oxford Hip or Knee Scores, the incidences of major post-operative complications, satisfaction and index joint improvement by A/D status. **Results:** 15.2% (254/1669) of patients were identified with anxiety and/or depression at time of surgery. In the unadjusted analysis, the A/D group had greater mean Oxford score improvement by 2.1 points (95% CI 0.8 to 3.4, $p = 0.001$), increased major complications (OR 1.39, 95% CI 1.05 to 1.85, $p = 0.02$), were less likely to report a "much better" global improvement for index joint (OR 0.56, 95% CI 0.38 to 0.83, $p = 0.003$), and there was no statistically significant difference in the rate of satisfaction with the results of surgery (OR 0.64, 95% CI 0.37 to 1.10, $p = 0.10$). The adjusted analysis found no significant associations between A/D vs. no-A/D and any of the reported outcomes. **Conclusion:** After adjustment for confounding variables, people with anxiety and/or depression pre-operatively, compared to those without, have similar outcomes following hip or knee arthroplasty.

Keywords

anxiety, arthroplasty, depression, orthopedics, outcomes

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Introduction

Elective primary total hip and knee arthroplasty (THA, TKA) procedures are common orthopaedic procedures aimed at improving the signs and symptoms associated with advanced osteoarthritis such as reduced mobility, pain and stiffness. While both procedures are effective in improving health domains,[1,2] as many as 28% of patients report dissatisfaction following surgery and up to 23% and 34% report long-term pain after THA or TKA, respectively.[3–6] Factors that have been linked to poorer outcomes include increased age and body mass index (BMI), female sex, medical comorbidities, reduced pre-operative mobility and increased pre-operative pain.[7,8]

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Patient psychological factors, specifically anxiety and depression, have been associated with increased medical and surgical complications, post-operative pain, chronic pain, opioid use, peri-operative disability and dissatisfaction following surgery.[3,9–15] Patients with mental health symptoms may experience impaired motivation, reduced participation in rehabilitation, increased pain sensitivity and catastrophizing behaviors, and have unrealistic expectations after surgery.[12] Psychological comorbidities not only influence individual patient recovery, but have also been associated with increased hospital length-of-stay, readmission rates, return-to-theater and costs.[16–19]

Despite what is known about the influence of psychological or mental health factors on outcomes following THA or TKA, there are several important limitations with the studies conducted to date including the wide variety of exposure measures that have been used. Many investigators have used patient-reported survey measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), 12-Item Short Form Survey (SF-12) and EuroQol-5D (EQ-5D) to identify mental health status.[20–22] The use of an objective measure of pre-operative mental health status, such as physician-diagnosed anxiety or depression being treated with medication has not been commonly used. We aimed to determine whether there is an association between physician-diagnosed anxiety or depression being treated with medication at the time of surgery, and outcomes at 1 year post-surgery (Oxford scores, post-operative complications, patient-reported satisfaction and patient-reported global index joint improvement) following primary elective total hip and total knee arthroplasty.

Materials and methods

The overarching study "Evidence-based Processes and Outcomes of Care (EPOC)" (ClinicalTrials.gov NCT01899443) explores the outcomes after primary THA and TKA in patients with osteoarthritis.[23] Using data from this prospective cohort study, we performed a secondary analysis of the association between anxiety/depression status and post-operative outcomes in consecutive patients involving 19 hospitals receiving primary THA or TKA between August 2013 and January 2015. Methods and outcomes for the overarching study have been previously published.[23–28] All patients in the original study were 18 years or older, provided written informed consent for their participation and were treated with total hip or knee arthroplasty for osteoarthritis as the primary diagnosis. Exclusion criteria for the original study were revision THA/TKA, patients with diagnosed cognitive impairment, and indications for surgery other than osteoarthritis such as avascular necrosis and fracture. Additional exclusion criteria for the current study were: patients receiving simultaneous bilateral THA/TKA; patients whose procedure was funded by workers compensation due to the impact of compensation status on post-operative function and satisfaction,[29,30] and patients who were diagnosed and treated for a mental health condition other than anxiety or depression (such as schizophrenia or bipolar disorder). The latter was justified on the grounds that anxiety and depression have been more extensively investigated than other psychological illnesses and we aimed to compare our results to extant research.

Pre-operative and acute care patient data including age, gender, body mass index (BMI) in kg/m^2, American Society of Anesthesiologists (ASA) score, education level, comorbidities and pre-operative patient outcomes and measures (PROMs) were collected at each hospital by site coordinators. A patient was considered to have a medical comorbidity if the patient was being actively treated for the condition with regular medication. Follow-up data were obtained from patients through telephone interview by research officers at 35 days, 90 days and 1 year post-surgery. Research staff audited all study data for accuracy with reference to electronic and paper-based medical records. PROMS outcomes were collected at 1 year post-surgery while complication data were collected at each time point and are a summation of results reported across the first year. Data were compiled the electronic research database software Redcap™.

The Oxford Hip and Knee scores provide an evaluation of joint-specific pain and function on a scale of 0 to 48 where a score of 48 corresponds to the best outcome and 0 the worst.[31,32] The minimal clinically important difference (MCID) for the Oxford score is estimated to be five points for either Oxford Hip Score (OHS) or Oxford Knee Score (OKS).[33] To evaluate patient satisfaction at 1 year post-surgery, participants were asked "How would you describe the results of your operation?" with possible responses of "poor," "fair," "good," "very good" or "excellent." We assessed patient-reported global index joint improvement at 1 year post-surgery using the Likert-type responses of "much worse," "a little worse," "same," "a little better" or "much better," which were given in response to the question "Overall, how are the problems now with your hip/knee compared to before your operation?" The global questions are used in the UK PROMs program.[34]

Using a two-part question, we asked study participants at the time of surgery whether they had received a diagnosis of anxiety and/or depression from a physician and, if so, were they being medically treated for this condition. If the answer to both questions was "yes," the person was considered to be part of the exposed group. The group with anxiety and/or depression (hereafter the "A/D" group) was compared to patients who did not meet these criteria (the "no-A/D" group). Medical treatments for anxiety and/or depression were cross-checked with medical records to ensure the accuracy of patient responses. The primary outcome was change in OHS or OKS from baseline to 1 year post-surgery. Secondary outcomes included major post-operative complications during the acute hospital stay and up to 1 year post-surgery, patient-reported satisfaction and

patient-reported global index joint improvement at 1 year post-surgery. Major complications included venous thromboembolism (VTE), reoperation, surgical site infection, wound dehiscence, significant joint bleed, intra-operative fracture, dislocation, cerebrovascular events (stroke or transient ischemic attack), major cardiac events (acute coronary syndrome or arrhythmia), other significant bleeding, adverse drug reactions, anaphylaxis, major system failure, neuropraxia and tendon rupture. Surgical site infection was defined as any suspected superficial or deep infection that was treated with oral or intravenous antibiotics, readmission or reoperation.

The sample size was dictated by the original study (1905 patients).[23,26] We planned to analyze THA and TKA cases separately for the current study, but as the patterns of both presentation and recovery were similar, we present the combined results here, adjusting for surgery type (results by surgery type are provided in Appendix 1). Using de-identified data, we described and compared exposure groups using means with standard deviations and t-tests, or proportions and chi-square tests, as appropriate. Baseline Oxford scores and change in Oxford score tend to be normally distributed allowing for analysis with parametric testing. We confirmed this with our data by assessing graphical distribution, skew and kurtosis, and we used the calculated change in Oxford score between baseline and 1 year post-surgery for analysis.[35] Our multivariate analysis of change in Oxford score included adjusting for baseline scores to account for the "ceiling effect" whereby higher baseline scores will limit the potential for improvement.[35,36] As very few people reported the worst outcomes, both the patient satisfaction and global improvement Likert scales were dichotomized prior to analysis. For satisfaction we compared "poor" and "fair" with "good," "very good" and "excellent." Similarly for global improvement we grouped "much worse," "worse," "same" and "a little better," and compared this with "much better." These thresholds were set as we thought that a satisfaction rating of "fair" and below, and similarly a global improvement rating of "a little better" and below did not justify the costs, recovery period and risks of surgery associated with THA and TKA.[37,38]

We performed unadjusted and adjusted analyses for all outcomes. We used a linear regression model to assess for associations in Oxford score change between groups, and a logistic regression model for major complications, patient-reported satisfaction and patient-reported global index joint improvement. All models were adjusted for suspected confounders such as age, gender, BMI, educational status, patient comorbidities, previous total joint arthroplasty and prescription opioid use at baseline. Our threshold for statistical significance was set at $p < 0.05$. No imputation was undertaken for missing data. All analyses were conducted using SPSS (version 23).[39] We did not find evidence of an interaction effect between age or gender and the exposure in any models. There was no evidence of multi-collinearity in the regression models.

Results

Of the 1905 participants included in the original study, 124 cases were excluded leaving 1781 eligible arthroplasty recipients (THA n = 811; TKA n = 970). After exclusion of 124 patients (n = 45 had incomplete data; n = 67 were lost to follow-up; n = 12 deaths), a total of 1669 people were included in the current study (Figure 1).

Participant characteristics

Characteristics of the study cohort are shown in Table 1, with 254 patients (15.2%) meeting the exposure criteria. While the mean age was similar across groups, at 66.2 years the A/D and 67.8 years for the no-A/D groups, the A/D group had a higher BMI at baseline, a greater proportion were obese (BMI $kg/m^2 \geq 30$ kg/m^2; 57.9% versus 46.4% respectively), and 71.7% were female, compared to 51.4% in the no-A/D group. The A/D group also had greater proportion of patients with diabetes, lung disease and lower back pain or other lower limb problems at baseline. They were also nearly twice as likely to be using prescription opioids pre-operatively as those without anxiety and/or depression (14.7% versus 7.4% for the A/D and no-A/D groups respectively).

Primary outcome

Mean Oxford scores at baseline were lower in the A/D group compared to the no-A/D group, denoting greater disability though not likely at a clinically meaningful level (18.1 vs. 21.9; $p < 0.001$). In the no-A/D group, Oxford scores on average increased by 21.5 points pre-operatively to 1-year post-operatively; this is compared to an increase of 23.6 points in the A/D group. Consequently, the unadjusted mean Oxford score change for the A/D group was 2.1 points greater (95% confidence interval [CI]: 0.8 to 3.4; $p = 0.001$) than that of the no-A/D group, denoting a greater improvement in score for the A/D group though this result falls below the minimum clinically important difference of 5 points and as such is unlikely to be clinically important.[33] After adjustment for potential confounders in multiple regression, this change decreased to a difference of 0.4 (95% CI: −1.2 to 0.5; $p = 0.38$) points lower for the A/D group compared to the no-A/D group (Table 2).

Secondary outcomes

Major complications. A total of 490 patients (29.4%) experienced a major complication over the 1 year follow-up period. The most frequent complication was surgical site infection, experienced by 193 patents (11.6%). Apart from VTE which was more common in the no-A/D group compared to the A/D group (4.2% vs. 2.8%), the other measured complications appeared to occur at a similar rate between the two groups (Table 3). The unadjusted odds ratio for experiencing a major complication to 1 year post-surgery

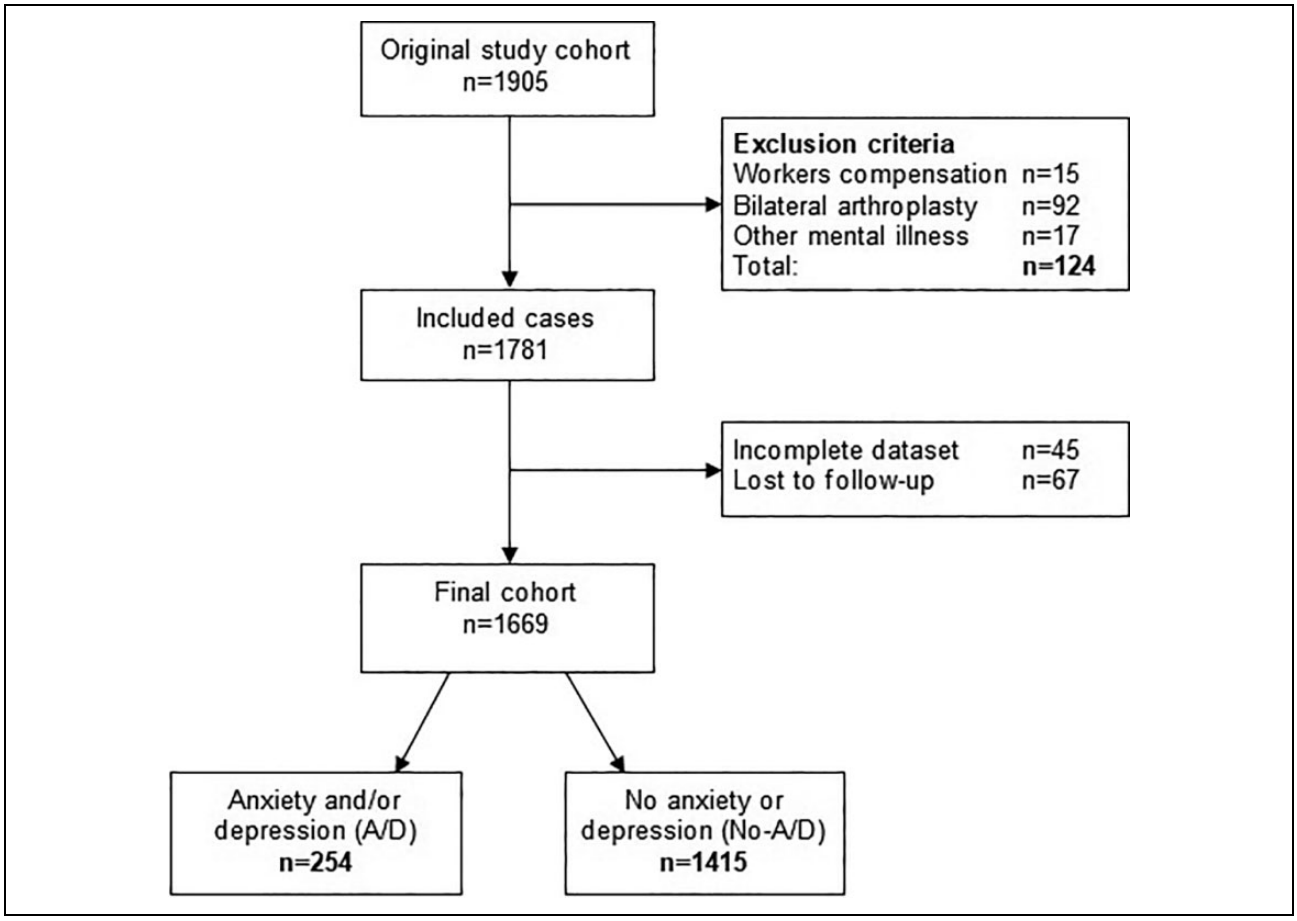

Figure 1. Study cohort.

in the A/D group compared to the no-A/D group was 1.39 (95% CI: 1.05 to 1.85; p = 0.02), which decreased to 1.23 (95% CI: 0.91 to 1.66; p = 0.18) in the adjusted analysis (Table 4).

Satisfaction. The distribution of patient satisfaction rating is shown in Table 3. The A/D group reported less satisfaction with their surgery at 1 year post-surgery, with an unadjusted OR of 0.64 (95% CI: 0.37 to 1.10; p = 0.10). This signal persisted in the adjusted analysis with an OR of 0.79 (95% CI: 0.45 to 1.38; p = 0.40) though neither result was statistically significant (Table 4).

Global improvement. The distribution of the joint improvement outcome is shown in Table 3. The A/D group reported less index joint global improvement at 1 year post-surgery, with an unadjusted OR of 0.56 (95% CI: 0.38 to 0.83; p = 0.003). After adjusting for possible confounders, the OR was 0.67 (95% CI: 0.44 to 1.01; p = 0.06) (Table 4).

Discussion

The A/D group, in comparison to the no-A/D group, had greater improvement in Oxford score but were more likely to have a major complication and also perceive less global joint improvement. These results were statistically-significant in our unadjusted analysis. The difference of 2.1 points for Oxford score, while clinically significant, was not interpreted to be clinically significant. When we considered the role of potential confounding factors in our adjusted analysis there was no statistically significant difference in any of the measured outcomes.

The rate of anxiety and/or depression in this study was 15.2%. This is comparable to other studies which note a rate of "depression only" of 9%[16] and 14.7%.[19] Two retrospective database studies from the United States with over one million THA or TKA recipients found rates of anxiety or depression to be 5.8%[40] and 4.6%.[41] We attribute the higher measured rate in the current study to our prospective study design and auditing systems to ensure accurate data capture.

Prior studies have identified mental illness to be associated with negative outcomes such as chronic pain, functional limitation and dissatisfaction following total hip or knee arthroplasty.[3,22,42] Our specific definition to evaluate mental health status differs to that of comparable studies which have used pre-surgical PROMs including WOMAC, SF12 and EQ5D to capture baseline mental health status and evaluate severity of mental illness.[20–22] The latter

Table 1. Baseline characteristics of the study population.

Variable	Anxiety and/or depression, n = 254	No anxiety or depression, n = 1415	p-value[1]
THA, n (% THA/(THA + TKA))	100 (39.4)	659 (46.6)	0.03
Age (years), mean (SD)	66.2 (9.1)	67.8 (9.8)	0.02
Female, n (%)	182 (71.7)	776 (51.4)	<0.001
BMI, mean (SD), kg/m^2	32.14 (6.90)	30.51 (6.29)	<0.001
BMI $\geq$ 30 (obese), n (%)	147 (57.9)	656 (46.4)	0.001
Comorbidity			
Cardiovascular disease, n (%)	56 (22.0)	293 (20.7)	0.63
Hypertension, n (%)	160 (63.0)	852 (60.2)	0.40
Kidney disease, n (%)	2 (0.8)	5 (0.4)	0.32
Liver disease, n (%)	10 (3.9)	32 (2.3)	0.12
Diabetes, n (%)	45 (17.7)	170 (12.0)	0.01
Current cancer, n (%)	6 (2.4)	16 (1.1)	0.11
Lung disease, n (%)	47 (18.5)	161 (11.4)	0.002
Central nervous system disease, n (%)	21 (8.3)	100 (7.1)	0.50
Bleeding disorder, n (%)	1 (0.4)	18 (1.3)	0.22
Lower back pain or other lower limb problems, n (%)	150 (59.1)	671 (47.5)	0.001
Highest education level			0.35
Year 8 or below, n (%)	40 (15.7)	174 (12.3)	
Year 9–10, n (%)	117 (46.1)	632 (44.8)	
Year 11–12, n (%)	54 (21.3)	323 (22.9)	
Degree, n (%)	43 (16.9)	282 (20.0)	
Previous arthroplasty, n (%)	71 (28.0)	403 (28.5)	0.86
Pre-operative opioid use[2], n (%)	37 (14.7)	104 (7.4)	<0.001
Length of stay, mean (SD), days	5.85 (3.23)	5.51 (2.40)	0.05

THA: total hip arthroplasty; SD: standard deviation; BMI: body mass index.
[1]Independent t-test used for linear variables, chi-square test used for nominal variables.
[2]Prescribed opioids only, i.e. oxycodone, oxycodone/naloxone, tapentadol, fentanyl, morphine.

Table 2. Oxford scores at baseline and follow-up, with between-group differences.

Variable	Anxiety and/or depression, **n = 254**	No anxiety or depression, **n = 1415**	p-value[1]
Baseline Oxford score, mean (SD)	18.07 (7.75)	21.89 (8.69)	<0.001
One year Oxford score, mean (SD)	41.70 (7.48)	43.39 (6.16)	0.001
Mean change in score (SD)	23.63 (9.48)	21.50 (9.78)	
Difference unadjusted[2], mean (95% CI)	2.14 (0.83 to 3.44)	—	0.001
Adjusted difference, mean (95% CI)	−0.36 (−1.17 to 0.45)	—	0.38

[1]Independent t-test used for baseline and unadjusted analysis, linear regression used for adjusted analysis.
[2]Anxiety and/or depression compared to no anxiety and/or depression; a positive result denotes a higher (better) score in the exposed (anxiety and/or depression) group.

approach is arguably a less precise way to categorize mental health. For example, patients using these PROMs may score poorly in mental health domains pre-operatively due to "situational depression" where psychiatric symptoms are largely attributed to the disability and pain associated with advanced osteoarthritis. Lower limb arthroplasty would therefore confer significant global improvement in this demographic.[43–45] Using more general health measures also allows other factors to influence recovery, satisfaction and improvement after hip and knee arthroplasty in addition to mental health status.[1–3,43,44,46] On the other hand, the strict definition we used to capture anxiety and depression status may have resulted in the inclusion of patients who had well-managed mental health illness, a demographic whose post-operative recovery may differ entirely to patients who experience significant disability secondary to untreated mental illness at the time of surgery.

By accounting for other variables such as age, BMI, opioid use and medical comorbidities, we were able to provide supporting evidence that factors apart from anxiety and depression status are likely influencing post-operative outcomes and possibly confounding the association with anxiety and depression. Performing an adjusted analysis to account for potential confounders has had limited implementation in the literature, which may provide explanation as to why our study results differ from other studies.[3,9] Factors such as medical comorbidities, experiencing a post-operative complication and surgical factors have been shown to be associated with a negative outcome post-operatively.[47] Differing from our definition of anxiety and depression status, prior research has explored two subsets of the depression category: those with "major depression" who are thought to experience limited benefit from lower limb arthroplasty, and those with "situational depression" whose psychiatric symptoms could be largely attributed to the disability and pain associated with advanced osteoarthritis.[43] In the latter group, lower limb arthroplasty may provide a significant improvement in mental health symptoms and benefit as much from the operation as patients with no diagnosis of anxiety or depression. As a result of this finding, it has been suggested that patients with depression should be treated for depressive symptoms before and after surgery to maximize outcomes overall and that surgeons should not be deterred from offering arthroplasty to this demographic.[43–45] As seen in our study cohort, patients

with anxiety and/or depression are also more likely to be taking opioid medication prior to surgery.[13,48] As opioid consumption is associated with undesirable outcomes post-surgery,[15] strategies aimed at reducing opioid consumption pre-surgery may also be relevant.

Table 3. Complications, satisfaction and global improvement at 1 year post-surgery by anxiety/depression status (total hip and total knee arthroplasty combined).

Variable	Anxiety and/or depression, **n = 254**	No anxiety or depression, **n = 1415**
Major complications, n (%)	90 (35.4)	400 (28.3)
Complications		
Surgical site infection, n (%)	42 (16.6)	151 (10.7)
Readmission, n (%)	25 (9.8)	119 (8.4)
Reoperation, n (%)	16 (6.3)	79 (5.6)
Venous thromboembolism, n (%)	7 (2.8)	59 (4.2)
Joint bleed, n (%)	6 (2.4)	43 (3.0)
Cardiac, n (%)	9 (3.5)	33 (2.3)
Wound dehiscence, n (%)	4 (1.6)	13 (0.9)
Fracture at surgical site, n (%)	3 (1.2)	12 (0.8)
Other bleed, n (%)	2 (0.8)	14 (1.0)
Major system failure, n (%)	2 (0.8	8 (0.6)
Dislocation, n (%)	2 (0.8)	7 (0.5)
Other fracture, n (%)	0 (0)	4 (0.3)
Cerebrovascular, n (%)	1 (0.4)	3 (0.2)
Neuropraxia, n (%)	1 (0.4)	3 (0.2)
Drug reaction, n (%)	0 (0)	3 (0.2)
Anaphylaxis, n (%)	0 (0)	0 (0)
Patient-reported satisfaction		
Poor, n (%)	10 (3.9)	24 (1.7)
Fair, n (%)	8 (3.1)	42 (3.0)
Good, n (%)	24 (9.4)	88 (6.2)
Very good, n (%)	49 (19.3)	253 (17.9)
Excellent, n (%)	163 (64.2)	1008 (71.2)
Patient-reported global improvement		
Much worse, n (%)	6 (2.4)	12 (0.8)
A little worse, n (%)	3 (1.2)	10 (0.7)
Same, n (%)	5 (2.0)	31 (2.2)
A little better, n (%)	23 (9.1)	70 (4.9)
Much better, n (%)	217 (85.4)	1292 (91.3)

Strengths and limitations

This study was well powered due to a large sample size and included a high proportion of THA cases in relation to TKA, with data points extending to 1 year post-surgery allowing for assessment of the benefits of hip and knee arthroplasty after patients were presumed to have sufficiently recovered from their surgery. Our secondary analysis of a prospective cohort study design aimed to minimize selection bias with detailed inclusion and exclusion criteria. We reduced the influence of recall bias by having data collection points at 30 days, 90 days and 1 year post-surgery. Other comparable studies have been retrospective in design, thus not all important covariates are likely to have been accounted for in these studies and bias is potentially introduced by knowing the outcomes prior to defining the relevant subgroups.[7,13,16,17] Our dataset provided rich clinical detail including specific patient comorbidities and post-operative complications which we were able to include in our statistical models to better represent our study groups.

We acknowledge the following limitations to our study. The observational data in this study limits our ability to infer causality in any association. Our definition of anxiety and depression status does not account for differing severity of illness and level of disability which may fluctuate over the duration of the study.[45] Future studies may choose to collect data on and compare objective and subjective measures of mental health to better understand the domains of improvement after total hip and knee arthroplasty. Other studies in comparison were able to evaluate this via PROMs mental health questionnaires. We also did not account for other treatments for anxiety and/or depression such as cognitive behavioral therapy in our definition; by controlling for this in another study subgroup (anxiety and/or depression without medical treatment) we may have been able to eliminate this confounder. We did not consider

Table 4. Unadjusted and adjusted association between anxiety and/or depression and secondary outcomes following total hip or total knee arthroplasty.

	Unadjusted		Adjusted[1]	
Variable	Odds ratio (95% CI)	p-value[2]	Odds ratio (95% CI)	p-value[2]
Major complications (any)	1.39 (1.05 to 1.85)	0.02	1.23 (0.91 to 1.66)	0.18
Satisfaction[3]	0.64 (0.37 to 1.10)	0.10	0.79 (0.45 to 1.38)	0.40
Global improvement[4]	0.56 (0.38 to 0.83)	0.003	0.67 (0.44 to 1.01)	0.06

[1]Adjusted for joint, age, sex, BMI, education status, pre-operative strong opioid use, previous total joint arthroplasty, comorbidities including cardiovascular disease, hypertension, kidney disease, liver disease, diabetes, current cancer, lung disease, central nervous system disease, bleeding disorder and lower back pain, and baseline Oxford score for Oxford score improvement.
[2]Logistic regression used for analysis.
[3]Dichotomized: compares "poor"/"fair" with "good," "very good" and "excellent."
[4]Dichotomized: compares "much worse," "worse," "same" and "a little better" with "much better."

the impact of psycho-pharmacological treatments, which may be risk factors for hospital readmission, increased hospital length-of-stay and increased post-operative complications thought to be attributed to side effect profiles in the peri-operative period.[12,16–19,49] Some of the included major complications, such as neuropraxia, may confer short-term disability in the immediate post-operative period but have limited impact on long-term outcomes. By dichotomizing the responses for the satisfaction and global improvement outcomes, the sensitivity was reduced in the pursuit of obtaining interpretable data. While both are scored similarly and contain the same number of items, the scores were not designed to be equivalent.[33] We also did not look at anxiety and/or depression status after surgery, which may have provided further insight on the effect of situational depression after the morbidity associated with advanced osteoarthritis was addressed.

We also combined Oxford hip and knee scores for analysis with consideration to study power; a potential limitation is that we have not provided the results by joint in the main text. As outcomes following THA have been less extensively investigated in the literature compared to TKA,[22,50] we had initially planned to provide results by joint, but given the patterns were similar we provided results for the combined cohort enabling a larger sample in the analysis. We note however that the "by joint" results are available in Appendix 1, and as such are available for pooled analyses in the future for meta-analyses. Future studies may also choose to study anxiety and depression as separate entities and compare the outcomes between these two groups.

Conclusion

Despite a lower baseline Oxford score and increased comorbid burden in the form of increased BMI, diabetes, lung disease and opioid use at the time of surgery, total hip or knee arthroplasty patients with physician-diagnosed anxiety and/or depression being medically treated at time of surgery appear to experience similar post-operative outcomes as patients who do not meet these criteria.

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Appendix 1

Table 1A. Baseline characteristics of the study population by joint (hip or knee).

	THA			TKA		
Variable	Anxiety and/or depression, n = 100	No anxiety or depression, n = 659	p-value[1]	Anxiety and/or depression, n = 154	No anxiety or depression, n = 756	p-value[1]
Age (years), mean (SD)	64.9 (9.4)	65.1 (10.8)	0.31	67.1 (8.9)	69.3 (8.5)	0.004
Female, n (%)	75 (75.0)	326 (49.5)	<0.001	107 (69.5)	410 (54.2)	<0.001
BMI, mean (SD), kg/m^2	29.89 (6.47)	29.01 (5.58)	0.20	33.59 (6.79)	31.82 (6.58)	0.003
BMI $\geq$ 30 (obese), n (%)	46 (46.0)	239 (36.3)	0.06	101 (65.6)	417 (55.2)	0.02
Comorbidity						
Cardiovascular disease, n (%)	15 (15.0)	106 (16.1)	0.78	41 (26.6)	187 (24.7)	0.62
Hypertension, n (%)	51 (51.0)	338 (51.3)	0.96	109 (70.8)	514 (68.0)	0.50
Kidney disease, n (%)	1 (1.0)	2 (0.3)	0.30	1 (0.6)	3 (0.4)	0.67
Liver disease, n (%)	6 (6.0)	11 (1.7)	0.006	4 (2.6)	21 (2.8)	0.90
Diabetes, n (%)	7 (7.0)	47 (7.1)	0.96	38 (24.7)	123 (16.3)	0.01
Current cancer, n (%)	2 (2.0)	4 (0.6)	0.14	4 (2.6)	12 (1.6)	0.39
Lung disease, n (%)	20 (20.0)	69 (10.5)	0.006	27 (17.5)	92 (12.2)	0.07
Central nervous system disease, n (%)	6 (6.0)	49 (7.4)	0.60	15 (9.7)	51 (6.7)	0.19
Bleeding disorder, n (%)	0	8 (1.2)	0.27	1 (0.6)	10 (1.3)	0.49
Lower back pain or other lower limb problems, n (%)	67 (67.0)	321 (48.7)	0.001	83 (53.9)	350 (46.4)	0.09
Highest education level			0.06			0.13
Year 8 or below, n (%)	12 (12.0)	50 (7.6)		28 (18.2)	124 (16.4)	
Year 9–10, n (%)	44 (44.0)	258 (39.4)		73 (47.4)	374 (49.5)	
Year 11–12, n (%)	16 (16.0)	182 (27.8)		38 (24.7)	141 (18.7)	
Degree, n (%)	28 (28.0)	165 (25.2)		15 (9.7)	117 (15.5)	
Previous arthroplasty, n (%)	30 (30.0)	185 (28.1)	0.69	41 (26.6)	218 (28.8)	0.58
Pre-operative opioid use[2], n (%)	17 (17.0)	63 (9.6)	0.03	20 (13.2)	41 (5.4)	0.001
Length of stay, mean (SD), days	5.33 (2.31)	5.03 (2.29)	0.23	6.19 (3.68)	5.92 (2.42)	0.25

THA: total hip arthroplasty; SD: standard deviation; BMI: body mass index.
[1]Independent t-test used for linear variables, chi-square test used for nominal variables.
[2]Prescribed opioids only, i.e. oxycodone, oxycodone/naloxone, tapentadol, fentanyl, morphine.

Table 2A. Oxford scores at baseline and follow-up, with between-group differences by joint.

	THA			TKA		
Variable	Anxiety and/or depression, n = 100	No anxiety or depression, n = 659	p-value[1]	Anxiety and/or depression, n = 154	No anxiety or depression, n = 756	p-value[1]
Baseline Oxford score, mean (SD)	17.24 (7.67)	21.56 (9.13)	<0.001	18.61 (7.78)	22.19 (8.29)	<0.001
One year Oxford score, mean (SD)	44.24 (6.07)	45.63 (4.91)	0.03	40.06 (7.87)	41.44 (6.47)	0.04
Mean change (SD)	27.00 (8.35)	24.07 (9.59)	—	21.45 (9.55)	19.25 (9.40)	—
Difference unadjusted[2], mean (95% CI)	2.93 (0.94 to 4.91)	—	0.004	2.20 (0.56 to 3.83)	—	0.009
Adjusted difference, mean (95% CI)	−0.37 (−1.46 to 0.71)	—	0.50	−0.24 (−1.41 to 0.94)	—	0.69

[1]Independent t-test used for baseline and unadjusted analysis, linear regression used for adjusted analysis.
[2]Anxiety and/or depression compared to no anxiety and/or depression; a positive result denotes a higher (better) score in the exposed (anxiety and/or depression) group.

Table 3A. Complications to 1 year post-surgery by anxiety/depression status and joint.

	THA			TKA		
Variable	Anxiety and/or depression, n = 100	No anxiety or depression, n = 659	p-value[1]	Anxiety and/or depression, n = 154	No anxiety or depression, n = 756	p-value[1]
Major complications	24 (24.0)	129 (19.6)	0.30	66 (42.9)	271 (35.8)	0.10
Complications						
Readmission	6 (6.0)	36 (5.5)	0.83	19 (12.3)	83 (11.0)	0.63
Venous thromboembolism	0 (0)	14 (2.1)	0.14	7 (4.5)	45 (6.0)	0.49
Reoperation	5 (5.0)	22 (3.3)	0.40	11 (7.1)	57 (7.5)	0.86
Surgical site infection	9 (9.0)	39 (5.9)	0.24	33 (21.4)	112 (14.8)	0.04
Wound dehiscence	1 (1.0)	1 (0.2)	0.12	3 (2.0)	12 (1.6)	0.74
Fracture at surgical site	2 (2.0)	9 (1.4)	0.62	1 (0.6)	3 (0.4)	0.67
Other fracture	0 (0)	1 (0.2)	0.70	0 (0)	3 (0.4)	0.43
Dislocation	2 (2.0)	7 (1.1)	0.42	0 (0)	0 (0)	
Joint bleed	4 (4.0)	14 (2.1)	0.25	2 (1.3)	29 (3.8)	0.11
Other bleed	1 (1.0)	7 (1.1)	0.96	1 (0.6)	7 (0.9)	0.74
Drug reaction	0 (0)	0 (0)		0 (0)	3 (0.4)	0.43

[1]Chi-square test used for analysis.

Table 4A. Satisfaction and global improvement at 1 year post-surgery by anxiety/depression status and joint.

	THA			TKA		
Variable	Anxiety and/or depression, n = 100	No anxiety or depression, n = 659	p-value[1]	Anxiety and/or depression, n = 154	No anxiety or depression, n = 756	p-value[1]
Satisfaction			0.07			0.37
Poor	4 (4.0)	6 (0.9)		6 (3.9)	18 (2.4)	
Fair	2 (2.0)	11 (1.7)		6 (3.9)	31 (4.1)	
Good	3 (3.0)	19 (2.9)		21 (13.6)	69 (9.1)	
Very good	16 (16.0)	75 (11.4)		33 (21.4)	178 (23.5)	
Excellent	75 (75.0)	548 (83.2)		88 (57.1)	460 (60.8)	
Improvement			0.26			0.03
Much worse	1 (1.0)	2 (0.3)		5 (3.2)	10 (1.3)	
A little worse	2 (2.0)	3 (0.5)		1 (0.6)	7 (0.9)	
Same	2 (2.0)	6 (0.9)		3 (1.9)	25 (3.3)	
A little better	2 (2.0)	16 (2.4)		21 (13.6)	54 (7.1)	
Much better	93 (93.0)	632 (95.9)		124 (80.5)	660 (87.3)	

[1]Chi-square test used for analysis.

Table 5A. Unadjusted and adjusted association between anxiety and/or depression and secondary outcomes by joint.

	THA				TKA			
	Unadjusted		Adjusted[1]		Unadjusted		Adjusted[1]	
	Odds ratio (95% CI)	p-value[2]	Odds ratio (95% CI)	p-value[2]	Odds ratio (95% CI)	p-value[2]	Odds ratio (95% CI)	p-value[2]
Major Complications	1.30 (0.79 to 2.13)	0.30	1.15 (0.67 to 1.97)	0.61	1.34 (0.94 to 1.91)	0.10	1.28 (0.88 to 1.86)	0.19
Satisfaction[3]	0.42 (0.16 to 1.08)	0.06	0.72 (0.25 to 2.09)	0.55	0.82 (0.43 to 1.58)	0.55	0.93 (0.47 to 1.85)	0.83
Global Improvement[4]	0.57 (0.24 to 1.34)	0.19	0.82 (0.33 to 2.06)	0.67	0.60 (0.38 to 0.95)	**0.026**	0.67 (0.39 to 1.06)	0.06

[1]Adjusted for joint, age, sex, BMI, education status, pre-operative strong opioid use, previous total joint arthroplasty, comorbidities including cardiovascular disease, hypertension, kidney disease, liver disease, diabetes, current cancer, lung disease, central nervous system disease, bleeding disorder and lower back pain, and baseline Oxford score for Oxford score improvement.
[2]Logistic regression used for analysis.
[3]Dichotomized: compares "poor"/"fair" with "good," "very good" and "excellent."
[4]Dichotomized: compares "much worse," "worse," "same" and "a little better" with "much better."