



Challenge Journal of PERIOPERATIVE MEDICINE

Research Article

Association of preoperative anxiety with acute postoperative pain after total knee arthroplasty

İrem Durmuş^{a,*} , Merve Bulun Yediyıldız^a , Irmak Çimenoglu^b 

^a Department of Anesthesiology and Reanimation, Kartal Dr. Lütfi Kırdar City Hospital, University of Health Sciences, İstanbul, Türkiye

^b Department of Anesthesiology and Reanimation, Tuzla State Hospital, İstanbul, Türkiye

ABSTRACT

Objective: Preoperative anxiety may influence postoperative pain perception and analgesic requirements. This study aimed to investigate the association between preoperative anxiety and acute postoperative pain during the first 24 hours following primary total knee arthroplasty.

Methods: This prospective observational cohort study included 100 adults undergoing elective primary total knee arthroplasty under spinal anesthesia. Preoperative anxiety was assessed using the Amsterdam Preoperative Anxiety and Information Scale (APAIS). Postoperative pain intensity was evaluated using the Numerical Rating Scale (NRS) at 1, 6, 12 and 24 hours. All patients received a standardized multimodal analgesic regimen and intravenous tramadol was administered as rescue analgesia when NRS scores were ≥ 4 . Associations between preoperative anxiety and postoperative pain were evaluated using correlation and multivariable regression analyses.

Results: The median APAIS anxiety score was 10.0 (IQR 5.0–15.0). Higher preoperative anxiety was significantly associated with higher postoperative pain scores at all evaluated time points during the first 24 hours (all adjusted $p < 0.001$). In multivariable analysis, preoperative anxiety remained independently associated with higher pain intensity at 24 hours after adjustment for age, sex and preoperative pain. Higher preoperative anxiety was also associated with greater cumulative rescue tramadol consumption during the first 24 postoperative hours.

Conclusion: Higher preoperative anxiety was associated with greater acute postoperative pain and greater cumulative rescue tramadol consumption after total knee arthroplasty. Preoperative anxiety screening may help identify patients at risk of more intense early postoperative pain and support individualized perioperative pain management strategies.

ARTICLE INFO

Article history:

Received – August 11, 2026
Revision requested – September 4, 2026
Revision received – September 5, 2026
Accepted – September 14, 2026

Keywords:

Preoperative anxiety
Total knee arthroplasty
Postoperative pain
APAIS
Tramadol



This is an open access article distributed under the CC BY licence.

© 2026 by the Authors.

Citation: Durmuş İ, Bulun Yediyıldız M, Çimenoglu I. Association of preoperative anxiety with acute postoperative pain after total knee arthroplasty. *Chall J Perioper Med.* 2026;4(3):144–151.

1. Introduction

Total knee arthroplasty (TKA) is a widely performed and effective surgical treatment for pain and functional impairment caused by advanced knee osteoarthritis. Despite advances in surgical techniques, regional anesthesia and multimodal analgesic strategies, acute postoperative pain remains a major clinical challenge after TKA.

Moderate-to-severe pain in the early postoperative period can delay mobilization and participation in rehabilitation, reduce patient satisfaction and increase the need for rescue analgesia [1]. The marked interindividual variability in pain and functional recovery after TKA also suggests that outcomes are influenced not only by surgical and analgesic factors but also by patient-specific characteristics.

* Corresponding author. E-mail address: irem.durmus89@gmail.com (İ. Durmuş)

ISSN: 2980-292X / DOI: <https://doi.org/10.20528/cjpm.2026.1322>

Postoperative pain is a complex, multidimensional experience that cannot be explained solely by the extent of surgical tissue injury. Preoperative pain intensity, age, sex, previous surgical experiences, expectations and psychological status may all influence how pain is perceived and reported. Among these psychological factors, preoperative anxiety is one of the most frequently investigated in relation to acute postoperative pain. Anxiety may heighten attention to painful stimuli, reinforce negative expectations and reduce perceived coping capacity. In addition, anxiety and acute pain share neurobiological and behavioral pathways that may interact bidirectionally [2].

The role of preoperative psychological status in outcomes after TKA has received increasing attention. Previous studies have shown that patients with greater preoperative anxiety, more severe pain and poorer functional status may report less favorable outcomes after surgery [3]. Similarly, preoperative anxiety has been associated with higher pain intensity, greater analgesic use and poorer early functional outcomes after TKA [4]. More recent prospective data also suggest that patients with symptoms of anxiety or depression may experience greater pain and worse patient-reported functional outcomes both before and after TKA [5]. However, much of the existing literature has focused on long-term functional outcomes, chronic pain or combined psychiatric diagnoses rather than acute postoperative pain.

Assessing preoperative anxiety with a standardized and practical instrument may help identify patients at greater risk before surgery. The Amsterdam Preoperative Anxiety and Information Scale (APAIS) is a brief, patient-reported measure developed to assess anxiety related to surgery and anesthesia, as well as the patient's need for information [6]. The Turkish version has demonstrated acceptable validity and reliability, supporting its use in perioperative clinical research in Türkiye [7]. Because the APAIS can be readily incorporated into routine preoperative assessment, it may be useful not only for research purposes but also for identifying patients who could benefit from additional psychological support or more individualized perioperative care. Although preoperative anxiety has previously been associated with outcomes after TKA, prospective evidence focusing specifically on acute pain during the first postoperative day remains limited. In this prospective cohort, preoperative anxiety was assessed using the APAIS and examined in relation to serial pain scores over the first 24 hours within a standardized spinal anesthesia and postoperative analgesia protocol. Cumulative rescue tramadol consumption was also evaluated as a complementary measure of early postoperative analgesic requirements.

The aim of this prospective observational cohort study was to investigate the association between preoperative anxiety, assessed using the APAIS, and acute postoperative pain intensity during the first 24 hours after elective primary TKA. We hypothesized that higher preoperative anxiety scores would remain independently associated with higher postoperative Numerical Rating Scale (NRS) pain scores after adjustment for relevant demographic and clinical variables.

2. Materials and Methods

2.1. Study design and ethical approval

This prospective observational cohort study was designed to evaluate the association between preoperative anxiety and acute postoperative pain intensity in patients undergoing elective primary TKA. The study was conducted in the operating rooms and relevant surgical wards of Tuzla State Hospital between May 2026 and August 2026. The study protocol was approved by the Koşuyolu High Specialization Training and Research Hospital Scientific Research Ethics Committee (decision date: April 21, 2026; decision no.: 2026/08/1449). The study was conducted in accordance with the principles of the Declaration of Helsinki. Before enrollment, all patients were informed about the purpose and procedures of the study and written informed consent was obtained from all participants.

2.2. Study population

Patients undergoing elective unilateral primary total knee arthroplasty (TKA) were assessed for eligibility according to the following criteria.

2.2.1. Inclusion criteria

- Age ≥ 18 years
- Scheduled for elective unilateral primary TKA
- American Society of Anesthesiologists (ASA) physical status I–III
- Planned spinal anesthesia

2.2.2. Exclusion criteria

- Previous total knee arthroplasty or revision surgery involving either the ipsilateral or contralateral knee
- Severe cognitive impairment
- Neurological or psychiatric disorders that could interfere with communication or reliable completion of the study questionnaires
- Chronic pain syndrome requiring regular opioid or neuropathic pain medication use
- Requirement for general anesthesia or sedation
- Known allergy or contraindication to paracetamol, diclofenac or tramadol

2.3. Preoperative assessment

Age, sex, height, body weight, body mass index, ASA physical status, comorbidities and history of previous surgery were recorded for all participants.

Preoperative anxiety was assessed using the Amsterdam Preoperative Anxiety and Information Scale. The APAIS consists of six items evaluating anxiety related to surgery and anesthesia and the patient's need for perioperative information. Each item was rated from 1 to 5. The four-item anxiety subscale has a total score ranging from 4 to 20, whereas the two-item information requirement subscale ranges from 2 to 10. Higher scores indicate greater anxiety or a greater need for information.

The APAIS was administered face to face by a trained investigator in the preoperative holding area before transfer to the operating room and before the administration of any sedative medication. Intravenous cannulation had already been performed in the surgical ward as part of routine preoperative care. The assessment was performed at a standardized preoperative time point under comparable conditions for all participants. The total APAIS anxiety subscale score was used as the primary independent variable in this study.

2.4. Anesthetic management

All patients underwent standard intraoperative monitoring, including electrocardiography, noninvasive arterial blood pressure monitoring and peripheral oxygen saturation. After intravenous access was established, spinal anesthesia was performed under aseptic conditions according to the institutional protocol. With the patient in the sitting position, the subarachnoid space was accessed at the L3–L4 or L4–L5 intervertebral level and 10–15 mg (2.0–3.0 mL) of 0.5% hyperbaric bupivacaine was administered intrathecally. No intrathecal opioid or other adjuvant was used. Adequacy of the spinal block was confirmed by bilateral pinprick assessment before the start of surgery. Surgery was initiated only after an adequate sensory block had been achieved. None of the patients included in the study received intraoperative sedation. Three patients required conversion from spinal to general anesthesia because of inadequate spinal blockade and were excluded from the final analysis.

Duration of surgery was recorded in minutes from skin incision to completion of skin closure.

2.5. Postoperative analgesia protocol

All patients received a standardized multimodal analgesic regimen consisting of intravenous paracetamol 1 g every 8 hours and intramuscular diclofenac sodium 75 mg every 12 hours. The first doses of intravenous paracetamol 1 g and intramuscular diclofenac sodium 75 mg were administered at the end of surgery. The pharmacological components of this standardized regimen were aligned with the PROSPECT recommendations for TKA, which recommend paracetamol and a nonsteroidal anti-inflammatory drug as basic analgesics, with opioids reserved for rescue analgesia [1]. No peripheral nerve block or periarticular local anesthetic infiltration was performed.

Postoperative pain intensity at rest was assessed using an 11-point Numerical Rating Scale ranging from 0 to 10, where 0 indicated no pain and 10 represented the worst pain imaginable. Pain assessments were performed at 1, 6, 12 and 24 hours after the end of surgery. Postoperative pain assessments were performed by an investigator who was blinded to the patients' preoperative APAIS scores. At each predefined assessment time point (1, 6, 12 and 24 hours after the end of surgery), the NRS score was recorded before the administration of rescue analgesia. Patients with an NRS score of 4 or higher received 100 mg intravenous tramadol as rescue analgesia, with a maximum total daily dose of 400 mg.

Rescue tramadol was administered only at these predefined assessment time points and the administered dose was recorded at each assessment.

2.6. Outcome measures

The primary outcome was the association between the preoperative APAIS anxiety score and the NRS pain score at 24 hours postoperatively. Secondary outcomes included the associations between the APAIS anxiety score and NRS scores at 1, 6 and 12 hours postoperatively, changes in postoperative NRS scores during the first 24 hours, the association between preoperative anxiety level and rescue tramadol requirements at different postoperative time points and the potential effects of demographic and clinical variables on postoperative pain intensity.

2.7. Sample size calculation

The sample size calculation was based on the primary hypothesis of an association between preoperative anxiety and postoperative pain, both analyzed as continuous variables. At the planning stage, reliable effect-size estimates for an adjusted multivariable regression model were not available; therefore, the calculation was based on detecting a moderate correlation between these two continuous measures. The minimum required sample size was determined using an a priori power analysis with G*Power 3.1. Assuming a moderate correlation coefficient ($r = 0.30$), a two-sided alpha level of 0.05 and 80% statistical power, a minimum sample size of 84 patients was required. To account for potential data loss or incomplete assessments, the target sample size was increased to 100 patients. The final multivariable model included four predictors and was kept parsimonious relative to the available sample size.

2.8. Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test together with graphical methods. Normally distributed variables are presented as mean $\pm$ standard deviation, non-normally distributed variables as median and interquartile range and categorical variables as counts and percentages.

The internal consistency of the APAIS anxiety and information requirement subscales was evaluated using Cronbach's alpha. Associations between preoperative APAIS anxiety scores and postoperative NRS scores were examined using Spearman rank correlation analysis. Holm–Bonferroni correction was applied to related multiple comparisons.

Changes in NRS scores at 1, 6, 12 and 24 hours postoperatively were analyzed using the Friedman test. When a significant overall difference was identified, pairwise comparisons were performed using the Wilcoxon signed-rank test with Holm–Bonferroni adjustment.

Covariates for the multivariable model were selected based on their clinical relevance to postoperative pain

while maintaining a parsimonious model. Preoperative NRS score, age, and sex were included as potential confounding variables. Previous surgical history and duration of surgery differed between the exploratory high- and low-anxiety groups; however, these post hoc group differences were not used to determine covariate inclusion in the primary model, in which APAIS anxiety score was analyzed as a continuous variable.

Multiple linear regression analysis was used to evaluate whether preoperative anxiety was independently associated with pain intensity at 24 hours. The 24-hour NRS score was entered as the dependent variable, while the APAIS anxiety score, preoperative NRS score, age and sex were entered simultaneously as independent variables. Regression results are presented as unstandardized regression coefficients, 95% confidence intervals and *p* values.

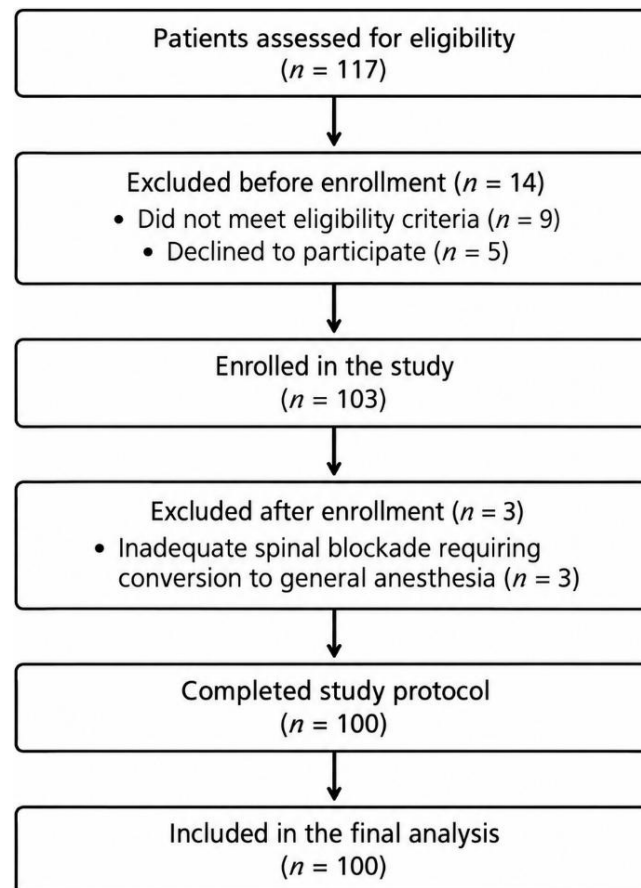
For exploratory analyses, patients were categorized into high- and low-anxiety groups using an APAIS anxiety subscale cut-off of ≥ 11 , as originally proposed by Moerman et al. [6]. Continuous variables were compared between groups using the independent-samples *t* test or

Mann–Whitney *U* test, as appropriate, and categorical variables were compared using the chi-square test or Fisher's exact test. Total tramadol consumption during the first 24 postoperative hours was calculated as the sum of the 100-mg rescue doses administered.

All statistical tests were two-sided and a *p* value < 0.05 was considered statistically significant.

3. Results

A total of 117 patients were assessed for eligibility. Fourteen patients were excluded before enrollment: nine did not meet the eligibility criteria and five declined participation. The remaining 103 patients were enrolled in the study. Three patients required conversion from spinal to general anesthesia because of inadequate spinal blockade and were excluded from the final analysis. None of the enrolled patients required intraoperative sedation. The remaining 100 patients completed the study protocol and were included in the final analysis. The participant flow is shown in Fig. 1.



No enrolled patient required intraoperative sedation.

Fig. 1. Participant flow diagram of the study.

The mean age was 67.34 ± 6.86 years, the mean body mass index was 32.26 ± 4.64 kg/m² and 64% of the cohort were women. Sixty-two patients (62%) were classified as ASA II and 38 (38%) as ASA III. The median preoperative NRS score was 7.0 (IQR, 6.0–7.0) and the median duration of surgery was 122.5 minutes (IQR, 110.0–

140.0). The median APAIS anxiety subscale score was 10.0 (IQR, 5.0–15.0) and the median information requirement subscale score was 4.0 (IQR, 2.0–6.0). Internal consistency was high for both subscales, with Cronbach's alpha values of 0.951 for anxiety and 0.948 for information requirement (Table 1).

Table 1. Demographic and clinical characteristics of the study population.

Variable	All patients (<i>n</i> = 100)	High anxiety (<i>n</i> = 48)	Low anxiety (<i>n</i> = 52)	<i>p</i>
Age (years)	67.34 ± 6.86	67.65 ± 7.34	67.06 ± 6.45	0.672
Female sex, <i>n</i> (%)	64 (64.0)	39 (81.3)	25 (48.1)	< 0.001
Body mass index (kg/m ²)	32.26 ± 4.64	32.77 ± 4.69	31.79 ± 4.58	0.292
ASA II/III, <i>n</i>	62/38	30/18	32/20	0.921
History of previous surgery, <i>n</i> (%)	50 (50.0)	17 (35.4)	33 (63.5)	0.005
Duration of surgery (min)	122.5 (110.0–140.0)	120.0 (103.8–126.3)	137.5 (120.0–150.0)	< 0.001
Preoperative NRS score	7.0 (6.0–7.0)	7.0 (6.0–7.0)	7.0 (6.0–7.0)	0.443
AP AIS anxiety subscale (4–20)	10.0 (5.0–15.0)	—	—	—
AP AIS information requirement subscale (2–10)	4.0 (2.0–6.0)	—	—	—

Data are presented as mean ± standard deviation, median (interquartile range) or *n* (%). High anxiety was defined as an AP AIS anxiety subscale score ≥ 11. Continuous variables were compared using the independent-samples *t* test or Mann-Whitney *U* test, as appropriate, and categorical variables were compared using the chi-square test. AP AIS, Amsterdam Preoperative Anxiety and Information Scale; ASA, American Society of Anesthesiologists; NRS, Numerical Rating Scale. High- and low-anxiety group comparisons were exploratory.

Preoperative AP AIS anxiety scores were positively and significantly correlated with NRS scores at all postoperative assessment points. Spearman correlation coefficients at 1, 6, 12 and 24 hours were 0.649, 0.680, 0.590

and 0.570, respectively (all adjusted *p* < 0.001). The strongest association was observed with pain intensity at 6 hours postoperatively (Table 2).

Table 2. Association between preoperative anxiety and postoperative pain scores.

Postoperative assessment	Spearman <i>ρ</i>	95% CI	Adjusted <i>p</i>
NRS at 1 hour	0.649	0.510–0.755	< 0.001
NRS at 6 hours	0.680	0.550–0.778	< 0.001
NRS at 12 hours	0.590	0.436–0.711	< 0.001
NRS at 24 hours	0.570	0.411–0.695	< 0.001

The explanatory variable was the AP AIS anxiety subscale score (4–20). Holm–Bonferroni correction was applied for multiple comparisons. AP AIS, Amsterdam Preoperative Anxiety and Information Scale; CI, confidence interval; NRS, Numerical Rating Scale.

In the multivariable linear regression model with the 24-hour NRS score as the dependent variable, the AP AIS anxiety score remained independently associated with greater pain intensity after adjustment for preoperative NRS score, age and sex (*B* = 0.144; 95% CI, 0.088–0.201;

p < 0.001). The model explained 37.1% of the variance in 24-hour pain scores. Male sex was associated with lower 24-hour NRS scores, whereas age and preoperative NRS score were not significantly associated with the outcome (Table 3).

Table 3. Multiple linear regression analysis of factors associated with pain intensity at 24 hours.

Variable	<i>B</i>	95% CI	<i>p</i>
AP AIS anxiety score	0.144	0.088–0.201	< 0.001
Preoperative NRS score	–0.178	–0.545–0.188	0.336
Age	0.007	–0.027–0.042	0.675
Male sex	–0.587	–1.141–0.032	0.039

The dependent variable was the NRS score at 24 hours postoperatively. All variables were entered simultaneously into the model. Model: *F*(4,95) = 13.99; *p* < 0.001; *R*² = 0.371; adjusted *R*² = 0.344. *B*, unstandardized regression coefficient; AP AIS, Amsterdam Preoperative Anxiety and Information Scale; CI, confidence interval; NRS, Numerical Rating Scale.

Postoperative pain intensity changed significantly over the first 24 hours (Friedman χ^2 [3] = 78.94; *p* < 0.001). Median NRS scores were 2.0 at 1 hour, 5.0 at 6 hours, 4.0 at 12 hours and 4.0 at 24 hours. Pain peaked at 6 hours, whereas the difference between the 12- and 24-hour scores was not statistically significant.

In exploratory analyses, 48 patients were classified as having high anxiety and 52 as having low anxiety. Pa-

tients in the high-anxiety group reported higher pain scores at every postoperative assessment point (all *p* < 0.001). Median cumulative tramadol consumption during the first 24 hours was also higher in the high-anxiety group [300 mg (IQR, 300–325) vs 200 mg (IQR, 100–200); *p* < 0.001]. The median cumulative tramadol dose during the first 24 hours was 200 mg (IQR, 175–300). Rescue tramadol was administered at least once to 98%

of patients and was most frequently required at the 6-hour assessment. No patient exceeded the maximum

daily dose of 400 mg. No intraoperative complications were observed (Table 4).

Table 4. Rescue tramadol consumption during the first 24 postoperative hours.

Variable	All patients (<i>n</i> = 100)	High anxiety (<i>n</i> = 48)	Low anxiety (<i>n</i> = 52)	<i>p</i>
Cumulative tramadol (mg)	200 (175–300)	300 (300–325)	200 (100–200)	< 0.001
Cumulative tramadol (mg/kg)	2.59 (1.88–3.75)	3.37 (3.06–4.30)	2.00 (1.16–2.52)	< 0.001
Patients requiring ≥ 1 rescue dose, <i>n</i> (%)	98 (98.0)	—	—	—

Data are presented as median (interquartile range) or *n* (%). Cumulative tramadol dose was calculated as the sum of the 100-mg doses administered according to the standardized rescue analgesia protocol. High anxiety was defined as an APAIS anxiety subscale score ≥ 11. High- and low-anxiety groups were compared using the Mann-Whitney *U* test. Group comparisons were exploratory. APAIS, Amsterdam Preoperative Anxiety and Information Scale.

4. Discussion

In this prospective observational study, higher preoperative anxiety was significantly associated with greater acute postoperative pain during the first 24 hours after elective primary TKA. As APAIS anxiety scores increased, NRS pain scores also increased across the postoperative assessment points and the association persisted after adjustment for relevant demographic and clinical variables. In the adjusted model, each one-point increase in the APAIS anxiety score was associated with a 0.144-point increase in the 24-hour NRS score, indicating a modest effect magnitude despite the statistically robust association. Accordingly, the continuous APAIS analyses and the adjusted regression model provide the stronger evidence for the association between preoperative anxiety and postoperative pain, whereas the high- versus low-anxiety group comparisons should be regarded as exploratory. Higher preoperative anxiety was also associated with greater cumulative rescue tramadol consumption. Together, these findings suggest that preoperative psychological status may have a clinically meaningful role in the early pain experience after TKA.

Our findings are broadly consistent with previous studies examining the relationship between preoperative anxiety and postoperative pain in patients undergoing TKA. Alattas et al. reported that greater preoperative anxiety, higher pain intensity and poorer functional status were associated with worse patient-reported outcomes after TKA [3]. Pan et al. similarly showed in a large patient cohort that anxiety and depression were associated with pain-related symptoms and postoperative complications following TKA [8]. More recent prospective data have also indicated that patients with symptoms of anxiety or depression may experience greater pain and worse subjective functional outcomes both before and after TKA [5]. In another orthopedic population, Nixon et al. found that patients with high preoperative anxiety undergoing foot and ankle surgery reported more residual pain and greater functional limitation after surgery [9].

Several neurobiological and behavioral mechanisms may help explain the relationship between preoperative anxiety and postoperative pain. Patients with greater anxiety may focus more strongly on painful stimuli, anticipate worse outcomes and experience a greater sense

of uncertainty or loss of control, all of which can amplify the pain experience. Anxiety and acute pain also share pathways related to stress responses, autonomic activation and central pain modulation [2]. In a descriptive correlational study of 138 patients undergoing elective general surgery, Gezer and Şişman reported positive associations between preoperative surgical fear and anxiety and postoperative pain intensity throughout the first 24 hours, with the relationship appearing most pronounced in the early postoperative period [10]. This supports our observation that anxiety was associated with pain at multiple postoperative time points across different types of surgery. However, that study found no significant association between anxiety or fear and total analgesic consumption. Differences in patient populations, surgical procedures, anxiety measures, and analgesic protocols may account for this discrepancy. The use of standardized spinal anesthesia and a uniform multimodal postoperative analgesic regimen in our study may have reduced variability attributable to anesthetic and routine analgesic management. Nevertheless, because of the observational design, a causal relationship between anxiety and postoperative pain cannot be established.

Because 98% of patients received at least one rescue tramadol dose, the more informative finding was the difference in cumulative tramadol consumption rather than whether rescue analgesia was required. This finding is also broadly consistent with previous literature. Ardon et al. reported higher opioid consumption on the day of surgery and the first postoperative day among patients using anxiolytic or antidepressant medications before TKA [11]. Although medication use is not a direct measure of anxiety severity, these findings support a possible relationship between psychological burden and early postoperative opioid requirements. Similarly, Rajamäki et al. found that patients using antidepressants or benzodiazepines before total hip or knee arthroplasty had more prolonged postoperative use of opioids and other analgesics [12].

The influence of psychological status on arthroplasty outcomes may extend beyond early pain and analgesic consumption. Harmer et al. reported higher risks of infection, revision and reoperation among patients with depression or anxiety undergoing total hip or knee arthroplasty [13]. Zalikha et al. likewise found that anxiety and depression may be associated with in-hospital com-

plications and healthcare outcomes after total joint arthroplasty [14]. Preoperative anxiety and depression have also been associated with higher direct costs and a greater burden of complications [15].

Not all studies, however, have reported consistent findings. In a multicenter analysis by Seagrave et al., some outcomes appeared less favorable in unadjusted analyses among patients receiving treatment for anxiety or depression, but these differences were no longer significant for one-year arthroplasty outcomes after adjustment for confounding variables [16]. This finding emphasizes that associations between psychological status and surgical outcomes may be influenced by factors such as age, sex, comorbidity, preoperative pain, and baseline function. In addition, a chronic psychiatric condition defined by diagnosis or medication use is not equivalent to short-term, surgery-specific anxiety. Differences in patient selection, assessment instruments, follow-up duration and outcome definitions are therefore likely contributors to the heterogeneity of the literature.

The higher anxiety levels and greater postoperative pain observed among women in our study are also consistent with previous findings. In a study using the APAIS, Celik and Edipoglu found significantly higher anxiety subscale scores in women and reported postoperative pain as one of the most common anesthesia-related concerns [17]. Their findings also support the practicality of the APAIS for identifying surgery and anesthesia-related anxiety during the preoperative visit. Nevertheless, the relationship between sex and pain should not be interpreted solely in biological terms. Pain perception and expression are shaped by a combination of hormonal, psychological, social and cultural influences. Moreover, the higher proportion of women in our high-anxiety group introduces potential confounding between sex and anxiety. Accordingly, even though sex was included in the multivariable analysis, these findings should not be interpreted as evidence of a direct biological causal effect.

The association between preoperative anxiety and acute postoperative pain has practical clinical implications because anxiety can be assessed easily before surgery and may be modifiable. The APAIS is brief, simple to administer and specifically addresses concerns related to anesthesia and surgery. Identifying patients with high anxiety before surgery could help target interventions such as more detailed counseling, realistic expectation setting, patient education, psychological support and individualized analgesic planning. However, our study does not demonstrate that reducing anxiety will necessarily reduce postoperative pain or opioid requirements. Randomized controlled trials comparing targeted preoperative education, cognitive-behavioral strategies or other anxiety-reducing interventions with standard care are needed to determine whether such approaches improve postoperative outcomes.

Preoperative psychological factors may also be relevant to longer-term pain outcomes. Croppi et al. identified anxiety and pain catastrophizing as risk factors for chronic pain after TKA [18]. Similarly, systematic reviews and meta-analyses evaluating the relationship between preoperative anxiety and chronic postsurgical pain suggest that anxiety may be an important marker of

longer-term pain vulnerability [19]. Because our study evaluated only the first 24 postoperative hours, we could not determine whether patients with greater anxiety and more intense early pain are also at increased risk of persistent pain in the months after surgery.

This study has several strengths. Its prospective design, inclusion of a relatively homogeneous primary TKA population, use of spinal anesthesia in all patients and standardized postoperative analgesic protocol reduced variability in perioperative management. Anxiety was assessed using a surgery-specific instrument with established validity in Turkish and pain was measured at multiple time points during the first 24 postoperative hours. In addition, adjustment for preoperative pain and key demographic variables allowed us to examine whether anxiety remained independently associated with postoperative pain.

Several limitations should also be considered. First, the single-center observational design precludes causal inference and may limit the generalizability of the findings to other patient populations or perioperative protocols. In addition, the exploratory high- and low-anxiety group comparisons may have been influenced by residual confounding because the groups differed in sex distribution, previous surgical history and duration of surgery; therefore, these subgroup findings should be interpreted cautiously. Second, the sample size was determined using a correlation-based calculation rather than specifically for the multivariable regression model; therefore, the study may have had limited power to detect smaller adjusted associations. Third, regression of the spinal sensory block was not systematically recorded; therefore, residual spinal anesthesia may have influenced the early postoperative NRS assessment, particularly at 1 hour. Fourth, other psychological factors that may influence postoperative pain, including depression, sleep disturbance, social support, expectations and pain-related self-efficacy, were not assessed. Fifth, pain is a subjective, patient-reported outcome and anxiety may influence both the perception and expression of pain. Sixth, because rescue tramadol was administered according to a standardized threshold of NRS ≥ 4 , the association between anxiety and tramadol requirement is not fully independent of pain intensity itself. Finally, only the first 24 postoperative hours were evaluated; longer-term outcomes such as length of hospital stay, mobilization, functional recovery, patient satisfaction and chronic postsurgical pain were not assessed.

5. Conclusions

Higher preoperative anxiety was associated with greater acute postoperative pain intensity and greater cumulative rescue tramadol consumption during the first 24 hours after elective primary TKA. These findings suggest that preoperative anxiety assessment may provide useful additional information when identifying patients who may experience greater early postoperative pain. Further multicenter and controlled studies are needed to determine whether interventions targeting preoperative anxiety can improve postoperative pain outcomes.

Acknowledgements

None declared.

Funding

The authors received no financial support for the research, authorship, and/or publication of this manuscript.

Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

AI Assistance

ChatGPT (OpenAI) was used for language refinement. The authors reviewed and verified the scientific content, statistical analyses, interpretations, and references and take full responsibility for the final manuscript.

Ethics Approval and Consent to Participate

This study was approved by the Koşuyolu High Specialization Training and Research Hospital Scientific Research Ethics Committee (Approval Number: 2026/08/1449; Date: April 21, 2026). Written informed consent was obtained from all participants. All procedures were conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations.

Author Contributions

İrem Durmuş: conceptualization, methodology, supervision, formal analysis, writing – original draft, writing – review & editing.

Merve Bulun Yediyıldız: conceptualization, methodology, supervision, data curation, investigation, writing – review & editing.

Irmak Çimenoglu: methodology, data curation, investigation, writing – review & editing.

REFERENCES

- Lavand'homme PM, Kehlet H, Rawal N, Joshi GP; PROSPECT Working Group of the European Society of Regional Anaesthesia and Pain Therapy. Pain management after total knee arthroplasty: PROcedure SPECific Postoperative Pain Management recommendations. *Eur J Anaesthesiol.* 2022;39(9):743-57. <https://doi.org/10.1097/EJA.0000000000001691>
- Michaelides A, Zis P. Depression, anxiety and acute pain: links and management challenges. *Postgrad Med.* 2019;131(7):438-44. <https://doi.org/10.1080/00325481.2019.1663705>
- Alattas SA, Smith T, Bhatti M, Wilson-Nunn D, Donell S. Greater preoperative anxiety, pain and poorer function predict a worse outcome of a total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(11):3403-10. <https://doi.org/10.1007/s00167-016-4314-8>
- Varış O, Peker G. Effects of preoperative anxiety level on pain level and joint functions after total knee arthroplasty. *Sci Rep.* 2023;13(1):20787. <https://doi.org/10.1038/s41598-023-48291-2>
- Aalders MB, van der List JP, Keijser LCM, Benner JL. Anxiety and depression prior to total knee arthroplasty are associated with worse pain and subjective function: a prospective comparative study. *Knee Surg Sports Traumatol Arthrosc.* 2025;33(1):308-18. <https://doi.org/10.1002/ksa.12336>
- Moerman N, van Dam FS, Muller MJ, Oosting H. The Amsterdam Preoperative Anxiety and Information Scale (APAIS). *Anesth Analg.* 1996;82(3):445-51. <https://doi.org/10.1097/0000539-199603000-00002>
- Çetinkaya F, Kavuran E, Ünal Aslan KS. Validity and reliability of the Amsterdam Preoperative Anxiety and Information Scale in the Turkish population. *Turk J Med Sci.* 2019;49(1):178-83. <https://doi.org/10.3906/sag-1806-84>
- Pan X, Wang J, Lin Z, Dai W, Shi Z. Depression and anxiety are risk factors for postoperative pain-related symptoms and complications in patients undergoing primary total knee arthroplasty in the United States. *J Arthroplasty.* 2019;34(10):2337-46. <https://doi.org/10.1016/j.arth.2019.05.035>
- Nixon DC, Schafer KA, Cusworth B, McCormick JJ, Johnson JE, Klein SE. Preoperative anxiety effect on patient-reported outcomes following foot and ankle surgery. *Foot Ankle Int.* 2019;40(9):1007-11. <https://doi.org/10.1177/1071100719850806>
- Gezer D, Şişman H. The effect of preoperative fear and anxiety on postoperative pain in surgical patients: a descriptive and correlational study. *Ir J Med Sci.* 2026 Apr 27. Online ahead of print. <https://doi.org/10.1007/s11845-026-04412-0>
- Ardon AE, Baloach AB, Matveev S, Colantonio MM, Narciso PM, Spaulding A. Preoperative anxiolytic and antidepressant medications as risk factors for increased opioid use after total knee arthroplasty: a matched retrospective cohort analysis. *Anaesthesiol Intensive Ther.* 2023;55(3):205-11. <https://doi.org/10.5114/ait.2023.130661>
- Rajamäki TJ, Moilanen T, Puolakkka PA, Hietaharju A, Jämsen E. Is the preoperative use of antidepressants and benzodiazepines associated with opioid and other analgesic use after hip and knee arthroplasty? *Clin Orthop Relat Res.* 2021;479(10):2268-80. <https://doi.org/10.1097/CORR.0000000000001793>
- Harmer JR, Wyles CC, Duong SQ, Morgan RJ 3rd, Maradit-Kremers H, Abdel MP. Depression and anxiety are associated with an increased risk of infection, revision, and reoperation following total hip or knee arthroplasty. *Bone Joint J.* 2023;105-B(5):526-33. <https://doi.org/10.1302/0301-620X.105B5.BJJ-2022-1123.R1>
- Zalikh A, Karabon P, Hajj Hussein I, El-Othmani MM. Anxiety and depression impact on in-hospital complications and outcomes after total knee and hip arthroplasty: a propensity score-weighted retrospective analysis. *J Am Acad Orthop Surg.* 2021;29(20):873-84. <https://doi.org/10.5435/JAAOS-D-20-00721>
- Rasouli MR, Menendez ME, Sayadipour A, Purtill JJ, Parvizi J. Direct cost and complications associated with total joint arthroplasty in patients with preoperative anxiety and depression. *J Arthroplasty.* 2016;31(2):533-6. <https://doi.org/10.1016/j.arth.2015.09.015>
- Seagrave KG, Lewin AM, Harris IA, Badge H, Naylor J. Association between pre-operative anxiety and/or depression and outcomes following total hip or knee arthroplasty. *J Orthop Surg (Hong Kong).* 2021;29(1):2309499021992605. <https://doi.org/10.1177/2309499021992605>
- Celik F, Edipoglu IS. Evaluation of preoperative anxiety and fear of anesthesia using APAIS score. *Eur J Med Res.* 2018;23(1):41. <https://doi.org/10.1186/s40001-018-0339-4>
- Croppi C, Delaigue F, Guinebertière V, Devriese F, Bizot P, Descamps J, et al. Catastrophism and anxiety are risk factors of chronic pain after total knee arthroplasty: a prospective cohort study. *Bone Jt Open.* 2025;6(7):755-63. <https://doi.org/10.1302/2633-1462.67.BJO-2024-0270.R1>
- Bakker-Bons M, Hijmering RMJ, Soer R, Wolff AP. The association between preoperative anxiety and chronic post-surgical pain after general anaesthesia, a systematic review and meta-analysis. *BJA Open.* 2025;16:100487. <https://doi.org/10.1016/j.bjao.2025.100487>