Journal of Orthopaedic Surgery and Research

RESEARCH

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Severe preoperative pain, functional decline, and high anxiety levels hinder the efficacy of multidisciplinary interventions in patients who underwent primary total knee arthroplasty

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Abstract

Background Patients experience clinically significant anxiety from the time they are recommended to undergo total knee arthroplasty (TKA). This study aimed to evaluate the efficacy of a preoperative intervention regarding anxiety levels in patients undergoing TKA for knee osteoarthritis (OA) and to evaluate whether patient characteristics affect the effectiveness of the intervention according to anxiety level.

Methods This retrospective observational study recruited 89 patients who underwent TKA under general anesthesia for knee OA. The preoperative multidisciplinary intervention comprised rehabilitation education and an interview with an orthopedic surgeon regarding surgical preparation status. The State-Trait Anxiety Inventory (STAI)-X was administered before and after the preoperative intervention. Patients with baseline clinically meaningful state anxiety (CMSA) status were divided into a group that improved to a non-CMSA status (improved group) and a group that showed no change in CMSA status after the preoperative multidisciplinary intervention (non-improved group).

Results The mean STAI-X score significantly decreased from 46.5 points before the preoperative multidisciplinary intervention to 37.4 points after the intervention ($P < 0.001$). The proportion of patients with CMSA also significantly decreased from 36.0% before the intervention to 14.6% after the intervention ($P < 0.001$). The preoperative pain scale score was significantly higher in the non-improved group than in the improved group. The Tegner activity level was significantly lower in the non-improved group than in the improved group. The preoperative knee function scores, KSS and WOMAC scores, in the non-improved group were significantly worse than in the improved group. Additionally, the preoperative STAI-X score was significantly higher in the non-improved group than in the improved group.

Conclusions For patients undergoing TKA, the implementation of a patient-specific preoperative multidisciplinary intervention, which consists of preoperative rehabilitation education and a surgeon interview, helps reduce

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preoperative anxiety. However, these preoperative multidisciplinary interventions may not be effective in patients who present with severe pain, poor functional status, or high anxiety levels before surgery.

Keywords Osteoarthritis, Total knee arthroplasty, Preoperative, Anxiety, Multidisciplinary intervention, Pain

Background

Total knee arthroplasty (TKA) is a common procedure performed to alleviate knee pain; more often than not it is caused by osteoarthritis (OA) [1]. Patients scheduled to undergo TKA are known to experience clinically significant anxiety from the moment they are recommended to undergo surgery [2]; therefore, anxiety intervention is required before surgery.

Currently, enhanced recovery after surgery protocols emphasize perioperative therapeutic strategies employed by surgeons and anesthesiologists, as well as the increased importance of preoperative patient education and interdisciplinary collaboration [3]. Preoperative education reduces perioperative anxiety by lowering the patient's postoperative expectations [4], and preoperative muscle strengthening and flexibility exercises aid in rapid recovery post-surgery [5]. Additionally, preoperative education and rehabilitation can reduce pain and improve patient satisfaction after TKA [6, 7].

Despite various perioperative interventions, some patients proceed with surgery because of significant anxiety. However, no research has been done on the characteristics of patients who are anxious due to a non-response to perioperative interventions [8–10]. This study aimed to evaluate the effectiveness of patient-specific preoperative multidisciplinary interventions in patients who underwent primary TKA. The primary endpoint was to evaluate changes in anxiety state before and after the preoperative multidisciplinary intervention, and the secondary endpoint was to compare the characteristics of the group whose anxiety state did not significantly improve after the preoperative multidisciplinary intervention with those of the improved group. By analyzing the characteristics of patients who do not respond to interventions such as preoperative rehabilitation or education, it may be possible to select patients who require a higher level of intervention, such as consulting a psychiatrist or taking anti-anxiety medications [11–14].

Methods

This retrospective study was conducted with the approval of the Institutional Review Board (IRB) of our institution (IRB No. 2024-01-015-002) and was performed according to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants.

Participants and inclusion criteria

This retrospective observational study recruited participants who underwent general anesthesia and TKA for knee OA between June 2023 and January 2024. This study consecutively enrolled patients aged > 60 years old with moderate or severe OA. Patients with rheumatoid arthritis, osteonecrosis, post-traumatic OA, a history of psychiatric disorders, or those who underwent second-stage bilateral TKA were excluded from this study.

Patient-specific preoperative multidisciplinary intervention

Figure 1 illustrates the perioperative process from the decision to perform surgery to the day of admission. After deciding to perform surgery, the baseline assessments was conducted immediately at the outpatient clinic. Baseline assessments included *(i)* demographic characteristics; age, sex, comorbidities, range of motion, knee OA grade, and deformity angle, *(ii)* social characteristics; religion and education level; *(iii)* preoperative pain and fuction level; the American Society of Anesthesiologists physical status (ASA-PS), numerical rating scale, Tegner activity scale, Knee Society Score (KSS), and Western Ontario and McMaster Universities (WOMAC) scores, and *(iv)* State-Trait Anxiety Inventory (STAI)-X survey. Subsequently, a clinical nurse specialist explained the preparation process for the surgery, hospital stay from admission to discharge, and general information regarding TKA surgery, general anesthesia, and complications the patient and guardian may experience. Preoperative rehabilitation education was provided twice a week in the 4th and 3rd weeks before surgery. Doctor in department of physical medicine and rehabilitation and professional physical therapists initiated quadriceps strengthening exercises preoperatively and taught rehabilitation methods postoperatively, including active range of motion exercises, continuous passive motion devices, and walking using a walker. Two weeks before surgery, the patient met with a surgeon who had performed TKA before. The surgeon in charge explained the overall preparation process for the patient's surgery; preoperative consultations, such as the opinion of the cardiologist on angina pectoris or the opinion of the nephrologist on chronic renal failure; and the level of risk of general anesthesia for each disease. Two weeks later, the patients were hospitalized and the second STAI-X survey was conducted.

Primary outcome: anxiety

The preoperative anxiety status was measured using the STAI-X before the intervention [15]. The STAI-X consists of 20 questions with a total score ranging from 20 to 80, with higher scores indicating greater anxiety. Clinically

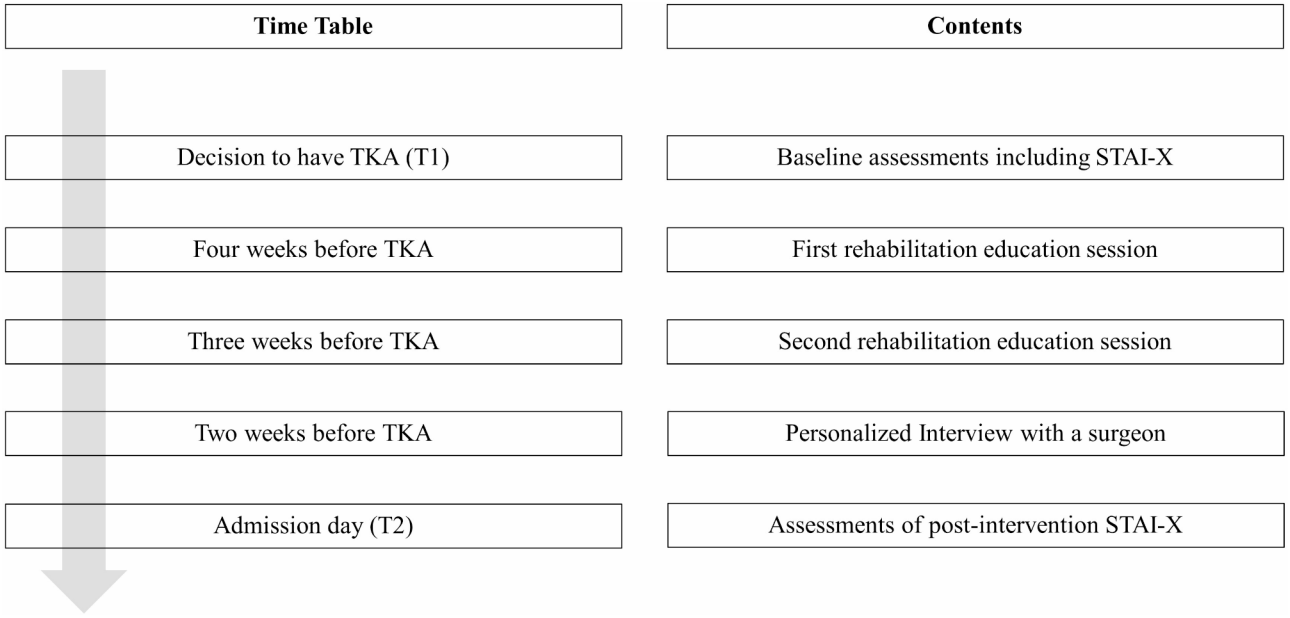

Fig. 1 Perioperative process from the decision to perform surgery to admission day. TKA: total knee arthroplasty; STAI: State-Trait Anxiety Inventory

meaningful state anxiety (CMSA) was defined as a total score of 52 [2, 15]. One orthopedic surgeon administered the two surveys. The first and second surveys were administered immediately before starting the intervention and on the day of hospitalization for surgery, respectively.

Secondary outcome: subgroup analysis

Patients with baseline CMSA status were divided into a group that improved to a non-CMSA status (improved group) and a group that showed no change in CMSA status after the preoperative multidisciplinary intervention (non-improved group).

Statistical analysis

Continuous variables are presented as means with standard deviations. Categorical variables were compared using the Chi-square test or Fisher's exact test, and continuous variables were compared using the Student's t-test, as appropriate. Multivariate analysis was performed using analysis of covariance to evaluate the association between patients' characteristics and CMSA improvement. Covariates included in the multivariate analysis were selected based on clinical importance and statistical significance and included demographic and social characteristics, preoperative pain, and function level. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 28 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $P < 0.05$.

Table 1 Demographics of the entire study population

Variables	*N* = 89
Sex	
Female: Male	68 (76.4): 21 (23.6)
Age, years	72.1 (60–87)
Height, cm	155.9 (142.9–175.4)
Weight, kg	66.3 (47.8–97.9)
Body mass index, kg/m^2	27.2 (21.6–39.1)
Hypertension (+: -)	68 (76.4): 21 (23.6)
Diabetes (+: -)	26 (29.2): 63 (70.8)
Range of motion, °	
Extension	-6.4 (-12.2–0)
Flexion	124 (85–140)
Hip-Knee-Ankle axis, °	7.6 (1.2–17.7)

Data are presented as N (%) or mean (range)

Results

Table 1 summarizes the demographic characteristics of the participants. All variables were normally distributed. Eighty-nine patients were enrolled in this study: 68 women (76.4%) and 21 men (23.6%) with a mean age of 72.1 years (range, 60–87 years).

Levels of preoperative anxiety

The mean STAI-X score significantly decreased from 46.5 points before the preoperative multidisciplinary intervention to 37.4 points after the intervention ($P < 0.001$; Fig. 2), and the proportion of patients with a CMSA status significantly decreased from 36.0% before the intervention to 14.6% after the intervention ($P < 0.001$; Table 2).

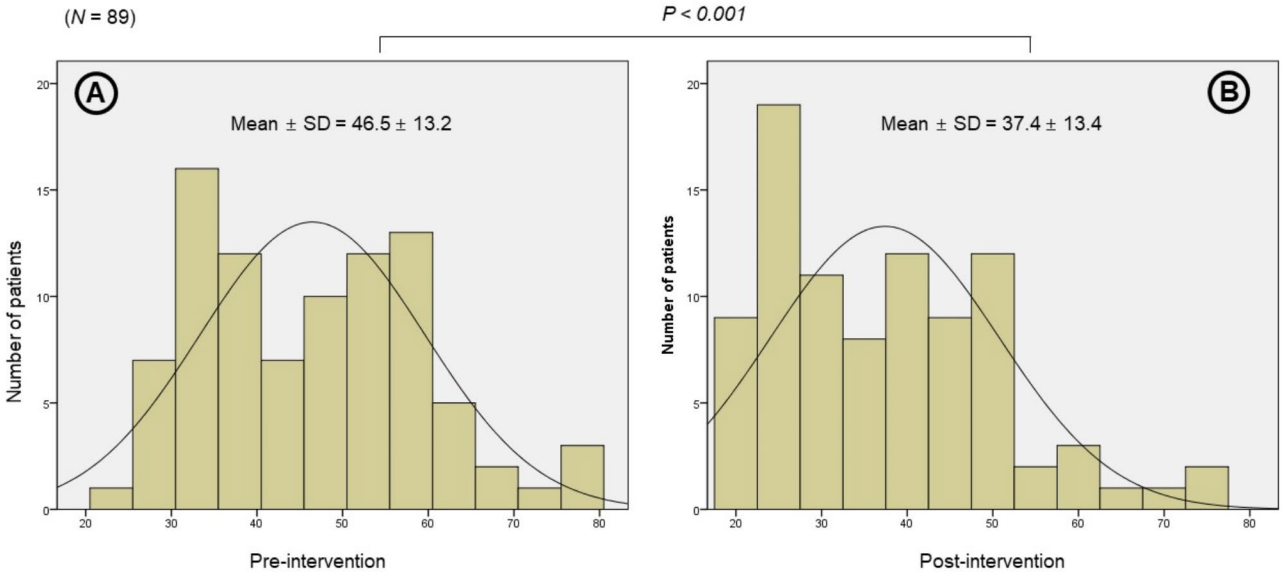

Fig. 2 Distribution of preoperative anxiety level before total knee arthroplasty. (**a**) Pre-intervention evaluation. (**b**) Post-intervention evaluation. The mean and standard deviation of STAI-X score significantly decreased from 46.5 ± 13.2 points before the preoperative multidisciplinary intervention to 37.4 ± 13.4 points after the intervention ($P < 0.001$). The curve represents a normal distribution curve

Table 2 Average preoperative anxiety score before and after intervention and proportion of patients with CMSA

N = 89	Pre-intervention	Post-intervention	*P* value
STAI-X score	46.5 (23–79)	37.4 (20–75)	< 0.001
Patients with CMSA	32 (36.0)	13 (14.6)	< 0.001

Data are presented as mean (range) or N (%)

Student's t-test were used to statistical analysis

CMSA: clinically meaningful state anxiety; STAI: State-Trait Anxiety Inventory

Preoperative CMSA and non-CMSA groups

No significant differences in the epidemiological, sociological, or functional characteristics were observed between the two groups, barring diabetes (Table 3). The proportion of patients with diabetes as a comorbidity was significantly higher in the CMSA group (50.0%) than in the non-CMSA group (17.5%; $P = 0.001$). The mean STAI-X before the preoperative multidisciplinary intervention

Table 3 Comparison between the patient group with baseline CMSA status and the group with non-CMSA status

	CMSA group (*n* = 32)	Non-CMSA group (*n* = 57)	*P* value
Demographics			
Age, year	73.4	71.3	0.07
Female ratio	26 (81.3)	42 (73.7)	0.43
Body mass index, kg/m^2	27.9	26.7	0.13
Hypertension +	28 (87.5)	40 (70.2)	0.07
Diabetes +	16 (50.0)	10 (17.5)	0.001
Social			
Religion (+: -)	22 (68.8): 10 (21.2)	34 (59.6): 23 (40.4)	0.39
Education level			0.17
None	3 (9.4)	2 (3.5)	
Elementary school	16 (50.0)	26 (45.6)	
Middle school	9 (28.1)	11 (19.3)	
> High school	4 (12.5)	18 (31.6)	
Functional status (mean)			
ASA-PS	2.4	2.5	0.81
Numerical rating scale	6.1	5.3	0.08
Tegner activity level	2.4	2.3	0.62
Knee Society Score	50.6	48.1	0.54
WOMAC score	51.1	46.9	0.33

Data are presented as mean (range) or N (%)

CMSA: clinically meaningful state anxiety; ASA-PS: The American Society of Anesthesiologists physical status; WOMAC: Western Ontario and McMaster Universities

Table 4 Comparison of characteristics of the group that improved to non-CMSA status after intervention with the non-improved group

	Improved group (*n* = 19)	Non-improved group (*n* = 13)	*P* value
Demographics			
Age, year	74.6	71.8	0.23
Female ratio	16 (84.2)	10 (76.9)	0.67
Body mass index, kg/m^2	28.1	27.7	0.74
Hypertension +	16 (84.2)	12 (92.3)	0.63
Diabetes +	10 (52.6)	6 (46.2)	0.72
Social			
Religion (+: -)	15 (79.0):	7 (53.9):	0.13
Education level			0.31
None	1 (5.3)	2 (15.4)	
Elementary school	11 (57.9)	5 (38.5)	
Middle school	6 (31.6)	3 (23.1)	
> High school	1 (5.3)	3 (23.1)	
Functional status (mean)			
ASA-PS	2.5	2.3	0.23
Numerical rating scale	4.9 (2–8)	7.2 (6–10)	< 0.001
Tegner activity level	2.7	2.2	0.007
Knee Society Score	56.6	41.8	0.03
WOMAC score	46.1	43.7	0.04
STAI-X score (mean)			
Pre-intervention	57.8 (52–63)	65.3 (54–79)	0.002
Post-intervention	46.9 (42–51)	59.5 (52–73)	< 0.001

Data are presented as N (%) or mean (range)

ASA-PS: The American Society of Anesthesiologists physical status; CMSA: clinically meaningful state anxiety; WOMAC: Western Ontario and McMaster Universities; STAI: State-Trait Anxiety Inventory

was significantly higher in the CMSA group (60.8 points) than in the non-CMSA group (38.4 points; $P < 0.001$). The mean STAI-X score after the preoperative multidisciplinary intervention was also significantly higher in the CMSA group (52.0 points) than in the non-CMSA group (29.2 points; $P < 0.001$).

Subgroup analysis of the improved and non-improved groups

Table 4 presents a comparison of the characteristics of the group that improved from CMSA to non-CMSA status and the non-improved group after the patient-specific preoperative multidisciplinary intervention. The preoperative pain scale score was significantly higher in the non-improved group (7.2 points) than in the improved group (4.9 points; $P < 0.001$). The Tegner activity level was significantly lower in the non-improved group (2.2 points) than in the improved group (2.7 points; $P = 0.007$). The preoperative knee function scores, KSS and WOMAC scores, in the non-improved group were 41.8 and 43.7 points, respectively, which were significantly worse than the 57.8 and 46.9 points in the improved group ($P = 0.03$ and 0.04, respectively). Multivariate analysis of variables within functional status was conducted and showed the preoperative pain scale and baseline STAI-X score showed significant factors related to CMSA improvement (Table 5).

Table 5 Multivariate logistic regression in the group that improved to non-CMSA status after intervention and the non-improved group

Variables	Coefficients	Standard errors	*P*-value
Numerical rating scale	0.106	0.044	0.02
Tegner activity level	-0.158	0.129	0.23
Knee Society Score	-0.006	0.018	0.75
WOMAC score	0.002	0.020	0.94
Baseline STAI-X score	0.028	0.009	0.005

WOMAC: Western Ontario and McMaster Universities; STAI: State-Trait Anxiety Inventory

Discussion

The most important finding of this study is that patient-specific preoperative multidisciplinary intervention consisting of individual interviews and rehabilitation education of patients undergoing primary TKA significantly decreased the STAI-X score. Furthermore, this study indicated that severe pain and decreased function contribute to the non-improvement of preoperative anxiety, despite patient-specific preoperative multidisciplinary interventions.

Timing of intervention

A previous study [16] reported that 38% of patients experienced the highest level of anxiety when the surgeon recommended TKA in an outpatient clinic. Despite suffering from chronic knee pain for a long time, patients who were recommended TKA as the last treatment method should decide on the date of surgery within a few minutes or days. These findings may be sufficient to induce anxiety among geriatric patients in outpatient clinics. Therefore, interventions to improve patients' anxiety levels between the time of TKA and hospitalization for surgery are recommended.

Preoperative outpatient interviews with surgeons

Jung et al. [2] reported that the most common cause of anxiety before TKA was the surgery itself and about 40% of patients experienced the greatest level of anxiety from the time they are recommended for TKA. One study reported that anesthesiologists explained different anesthetic options before surgery and provided counseling on anxiety related to anesthesia and surgery [17]. Previous studies on surgery-related anxiety have similarly reported that trust in medical staff is worthwhile in helping patients overcome preoperative anxiety [2, 18, 19]. Therefore, in this study, the surgeon who would perform TKA conducted the final interview with the patient and

answered the patient's questions related to the surgery and hospitalization.

Effectiveness of preoperative multidisciplinary intervention

Preoperative multidisciplinary intervention improves not only patient anxiety but also postoperative outcomes. Medina-Garzon [20] evaluated the effectiveness of a nursing intervention with three sessions of motivational interviewing to reduce preoperative anxiety in patients who underwent TKA and reported that anxiety levels improved after the intervention. Ho et al. [21] introduced a patient-specific integrated education program into the TKA clinical pathway and reported that anxiety status improved after the intervention regarding STAI-X scores during hospitalization. This study evaluated anxiety levels before and after preoperative multidisciplinary intervention in the same patients and indicated that anxiety levels significantly decreased after intervention compared with those before intervention. Preoperative education improves surgical outcomes in patients who underwent TKA [7, 16, 21–23]. Although preoperative education is embedded in the consent process, it is unclear whether it offers benefits regarding anxiety reduction over usual care [24]. A systematic review and meta-analysis [23] conducted to determine the efficacy of preoperative education and/or exercise on postoperative outcomes in patients undergoing TKA reported significant improvements in function, quadriceps strength, and length of stay. However, the trials included in that systematic review differed, in that, they evaluated whether preoperative education affected postoperative anxiety, whereas this study evaluated whether preoperative intervention affected preoperative anxiety.

Speculative mechanisms that respond poorly to the intervention

Olsen et al. [25] reported that more severe preoperative pain and anxiety symptoms increased likelihood of moderate-to-severe pain or functional impairment after TKA. Alattas et al. [26] reported that greater anxiety, preoperative pain and function were the most significant factors to predict a poorer outcome of a TKA. From these, it can be assumed that preoperative pain, preoperative functional status, and preoperative anxiety level are interrelated. Similarly, this study indicated that patients with severe pain, decreased function, and high anxiety levels did not respond to preoperative interventions consisting of rehabilitation education and additional interviews with surgeons. A previous meta-analysis employing random-effects models indicated substantial correlations between the key elements of the Fear-Avoidance Model (including pain catastrophizing, fear of pain, and pain vigilance) and adverse pain-related outcomes, such as negative effects, anxiety, depression, and disability [27]. Researches by Crombez et al. [28] and Wong et al. [29] suggested a potential bidirectional relationship between pain-related negative affect and fear of pain, with the former possibly triggering the latter. It has been proposed that negative emotional responses to pain (e.g., anger, shame, helplessness) might emerge as a consequence of experiencing fear [30]. The findings from previous meta-analyses align with the Fear-Avoidance Model of Chronic Pain [29, 31], indicating that both pain catastrophizing and fear of pain may precede pain-related mental health issues and disability.

Demand for a high level of intervention

Previous studies [32, 33] have evaluated the efficacy of anti-depressant 6 months before cervical spine surgery in patients with a history of anxiety or depression and reported that pretreatment for affective disorders significantly improved clinical outcomes. Wang et al. [34] reported that postoperative pain improved when duloxetine was administered to centrally sensitized patients who underwent TKA. Alattas et al. [26] recommended that patients presenting with symptoms of anxiety and depression should be identified and consulted before a TKA. Therefore, the administration of anti-anxiety or anti-depressant to patients with a history of anxiety or centrally sensitization would improve postoperative pain and perioperative anxiety symptoms. Both augmented and virtual reality-based interventions have been considered simpler, safer, and more effective for reducing anxiety in patients undergoing surgery than traditional perioperative education [35–37].

Strengths and weaknesses of this study

To the best of our knowledge, this is the first study to evaluate the effectiveness of a surgeon-directed preoperative intervention in reducing preoperative anxiety in patients undergoing TKA, regarding changes in STAI-X and the proportion of patients with CMSA. Moreover, this study established that the characteristics of patients whose CMSA status did not improve despite preoperative intervention suggested the need for appropriate additional intervention. Further studies are needed to determine the effects of the administration of anti-anxiety or anti-depressant to patients who do not improve with non-CMSA despite patient-specific preoperative multidisciplinary intervention.

This study had certain limitations. First, the sample size was small; only geriatric patients who underwent TKA for knee OA at a single institution were included. Additionally, the generalizability of the findings may be limited. Second, it was not possible to determine which of the two programs, rehabilitation education or surgeon interviews, was more effective in reducing patient

anxiety. Third, we assessed the characteristics of non-responders using demographic, social, and clinical factors. However, we could not evaluate various factors that could not be verified with objective numbers such as rapport with staff, previous experience or knowledge of surgical procedures, personal characteristics, and susceptibility to stressful situations. Finally, this study did not evaluate whether the participants whose anxiety levels improved before TKA experienced improvements in their postoperative pain or functional scores. In cases of total joint replacement, patients who receive preoperative education reportedly exhibit greater mobility in the immediate postoperative period and a shorter length of stay [16]. Therefore, mid- to long-term follow-up evaluations of the participants are necessary to evaluate differences in postoperative outcomes.

Conclusions

For patients undergoing TKA, the implementation of a patient-specific preoperative multidisciplinary intervention, which consists of preoperative rehabilitation education and a surgeon interview, helps reduce preoperative anxiety. However, these preoperative multidisciplinary interventions may not be effective in patients who present with severe pain, poor functional status, or high anxiety levels before surgery. Thus, higher levels of preoperative multidisciplinary intervention for anxiety may be necessary.

Abbreviations

TKA	Total knee arthroplasty
OA	Osteoarthritis
STAI	State-Trait Anxiety Inventory
CMSA	Clinically meaningful state anxiety
ASA-PS	American Society of Anesthesiologists physical status
KKS	Knee Society Score
WOMAC	Western Ontario and McMaster Universities
IRB	Institutional Review Board

Acknowledgements

Ji-Soo Choi (Clinical nurse specialist, Department of Orthopedic Surgery, Ulsan University Hospital, Ulsan, Republic of Korea)We would like to thank Editage (www.editage.co.kr) for English language editing.

Author contributions

D.-S. Yang: collection of data, data analysis, interpretation, and manuscript writing and revision. Y.D. Jeon: collection of data, data analysis, interpretation, and manuscript writing and revision. C.-R. Kim: collection of data, data analysis, and manuscript writing. S.-G. Kim: collection of data, data analysis, interpretation, and manuscript writing. K.-B. Park: conception, study design, interpretation, and manuscript writing and revision. All authors read and approved the final manuscript.

Funding

Not applicable.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Ulsan University Hospital (No. 2024-01-015-002). And written informed consent was obtained from all subjects and/or their legal guardian(s).

Consent for publication

Consent for publication was obtained from each participant in this study.

Competing interests

The authors declare no competing interests.

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Received: 13 November 2024 / Accepted: 10 February 2025
Published online: 20 February 2025

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