

Pain Catastrophizing and Acute Post-Surgical Pain in Knee Arthroplasty Patients: The Moderating Role of Social Support

Shanshan Ai^{1,*}, Yue Wang², Pengli Niu², Wenjun Xiao², Guojun Xu², Chang Zhu^{3,*}

¹Department of Nursing, Linping District Hospital of Integrated Traditional Chinese and Western Medicine, Hangzhou, Zhejiang, People's Republic of China; ²Department of Nursing, The First Hospital of Dalian Medical University, Dalian, Liaoning, People's Republic of China; ³Department of Expanded Program on Immunisation, Linping District Centre for Disease Control and Prevention, Hangzhou, Zhejiang, People's Republic of China

*These authors contributed equally to this work

Correspondence: Guojun Xu, Department of Nursing, The First Affiliated Hospital of Dalian Medical University, No. 222, Zhongshan Road, Xigang District, Dalian, Liaoning, 116011, People's Republic of China, Email xgj1973@163.com

Purpose: This study aimed to investigate the correlation between preoperative pain catastrophizing and social support, and acute post-surgical pain in patients who underwent knee arthroplasty. The study also aimed to determine whether social support moderates the role of pain catastrophizing psychologically in acute post-surgical pain after knee arthroplasty.

Patients and Methods: This study recruited participants to survey a tertiary hospital in Dalian, China, between November 2022 and October 2023. Participants completed pain catastrophizing scales and social support reevaluated scales one day (T1) before they were confirmed to undergo knee arthroplasty, and finished the Numeric Rating Scale at 24h (T2), 48h (T3), and 72h (T4) postoperatively. Pearson correlation analyses were used to explore the relationship between social support, pain catastrophizing, and acute post-surgical pain, hierarchical regression analysis was used to test the moderating role of social support between pain catastrophizing and acute post-surgical pain.

Results: This study recruited 178 knee arthroplasty patients. The results of the *t*-test or one-way ANOVA indicated that there were statistically significant differences in gender, age, education, occupation, disease duration, whether the knee replacement was performed for the first time, preoperative pain scores, and operation time in patients with knee arthroplasty ($P < 0.05$). The correlation analysis of social support, pain catastrophizing, and acute post-surgical pain in knee arthroplasty patients showed that social support was negatively correlated with acute post-surgical pain ($r = -0.584$, $P < 0.01$), and pain catastrophizing was positively correlated with postoperative acute pain ($r = 0.601$, $P < 0.01$); The hierarchical regression analysis revealed that social support had a significant moderating effect on the relationship between pain catastrophizing and acute post-surgical pain ($\Delta R^2 = 0.606$, $P < 0.05$).

Conclusion: The acute post-surgical pain of knee arthroplasty patients was affected by gender, age, education, occupation, disease duration, whether the knee arthroplasty was performed for the first time, preoperative pain scores, and operation time. Acute Post-surgical pain in patients with knee arthroplasty was affected by social support and pain catastrophizing, and social support had a moderating effect on the relationship between pain catastrophizing and acute post-surgical pain.

Keywords: knee arthroplasty, pain, pain catastrophizing, social support

Introduction

KOA (Knee Osteoarthritis) is the most prevalent form of degenerative joint disease.¹ with the aging of the population, the incidence of KOA continues to rise each year. KA (Knee Arthroplasty) is a common orthopedic surgical procedure for the treatment of end-stage KOA.^{2,3} According to a global epidemiological survey, the number of artificial joint replacements in China is nearly 400,000 per year, with an increase of 25–30%.⁴ From 2005 to 2030, the number of KA patients will increase by 297% in the Netherlands and by 673% in the US, The rise in the number of knee arthroplasty puts pressure on the health resources.^{5,6}

According to relevant studies, 44% of KA patients suffered from acute post-surgical pain, and up to 15% of patients developed extreme pain after surgery.⁷ Early functional exercises after knee arthroplasty have been found to promote the recovery of limb function and reduce the risk of postoperative complications. The occurrence of acute post-surgical pain not only influences the patient's post-surgical functional exercise but also causes fear, chronic pain, and mood disorders.⁸ Therefore, it is critical to understand the factors of influencing acute post-surgical pain in knee arthroplasty patients to reduce acute post-surgical pain.

With the rise of rapid rehabilitation surgery, pain management has also become a critical concern. Currently, greater progress has been made on the mechanisms of pain occurrence and effective analgesic drugs, but the results of pain management are still unsatisfactory in clinical practice.^{9,10} The biopsychosocial model of pain acknowledges the role of social and psychological factors in the experience of pain.¹¹ Social support is the provision of psychological, and material resources through social networks (family, friends, colleagues, etc). to improve an individual's coping skills, it is an external resource that is available to the individual.^{12,13} According to recent findings, social support has been shown to have a significant relationship with pain adaptation, patients with high levels of social support tend to exhibit greater pain adaptation.¹⁴ Pain catastrophizing is an exaggerated negative psychological condition that individuals experience during painful situations.^{13,15}

Studies have indicated that increasing social support can help reduce pain catastrophizing in cancer patients with head and neck tumors.¹⁶ In patients with KA, pain catastrophization impacts acute post-surgical pain.¹⁷ Therefore, in patients with KA, social support may exert similar effect. By enhancing social support, it may be possible to reduce the degree of pain catastrophizing. This may have an impact on acute post-surgical pain. In summary, this study aims to explore potential pathways of association between these variables using moderating effects and provide effective prevention and intervention measures for reducing acute post-surgical pain in patients with KA.

Materials and Methods

Participants and Procedure

This study recruited participants to survey a tertiary hospital in Dalian, China, between November 2022 and October 2023. The study complied with the principles outlined in the Declaration of Helsinki and was also approved by the Ethics Committee of the First Hospital of Dalian Medical University (PJ-KS-KY-2023-40). The participants were selected based on the following criteria: 1) Patients whose preoperative diagnosis met the diagnostic criteria for osteoarthritis of the knee in the Diagnostic Guidelines for Osteoarthritis (2021 edition),¹⁸ and who underwent knee arthroplasty after ineffective conservative treatment; 2) Age ≥ 18 years; 3) Clear consciousness and no obstacle to verbal communication; 4) Informed consent and voluntary participation in this study. Participants with other severe organic lesions, who were unable to cooperate with this study, or withdrew midway, are excluded from the study. Eligible participants were invited to participate by the investigators of this study, who provided information about the study's researchers, its purpose, methods, benefits, and potential risks. When participants were fully informed about the study, they signed an informed consent form and completed a questionnaire at the inpatient. The questionnaire consisted of socio-demographic information and relevant clinical and therapeutic information about the disease, Social Support Revalued Scale, Pain Catastrophizing Scale, and the Numerical Rating Scale, the socio-demographic information and relevant clinical and therapeutic information about the disease were obtained by the researcher who got the data from the hospital cases. Completion of the completed questionnaire was reviewed and collected by the researcher to minimize data loss.

Preoperative: all participants were instructed in the use of the Numeric Rating Scale; Intraoperative: all participants underwent surgery by the same team of surgeons under general anesthesia; Postoperative: the same analgesic regimen is used and knee exercises are performed by the same team of surgeons. After study registration, data collection was conducted face-to-face by the researcher, adhering to the same guidelines. The collection data was reviewed on the spot and checked line by line to ensure its completeness. The survey took approximately 25 minutes to complete.

The sample size was calculated using M. Kendall's empirical estimation method of sample content, which required a minimum of 5–10 times the size of the dependent variable.¹⁹ In this study, the sample was determined to be 178 cases by taking seven times the number of independent variables and accounting for a 10% null response rate. The first survey was

conducted on the day before knee arthroplasty surgery, with 187 participants completing the Pain Catastrophizing and Social Support Questionnaire (Time 1: T1). At Time 2 (24 hours postoperatively), 183 participants were enrolled in the study, with four participants excluded due to not undergoing knee arthroplasty surgery. At Time 3 (48 hours postoperatively), 183 participants were evaluated. At Time 4 (72 hours postoperatively), 178 participants were included in the study, with five participants excluded due to being discharged less than 72 hours postoperatively. The participants were requested to complete the Numeric Rating Scale at T2, T3, and T4.

Measures

Sample Characteristics

Socio-demographic data and relevant clinical and therapeutic information about the disease included participants' age, gender, height and weight, marital status, education, occupation, and disease duration.

Social Support

Social support was assessed using the Chinese Version of the Social Support Revalued Scale (SSRS).²⁰ The scale consists of 3 dimensions (objective support, subjective support, and utilization of support) and 10 entries. The total score is the sum of entries, ranging from 12 to 66, the higher total score indicates better social support. This scale was used to assess the level of social support of the patients in this study, and the Cronbach's α coefficient for this scale in this study was 0.736.

Pain Catastrophizing

The Chinese version of the Pain Catastrophizing Scale (PCS) was used to assess pain catastrophizing.²¹ The scale consists of 3 dimensions (rumination, exaggeration, helplessness) with 13 entries, each rated from "not at all" (score = 0) to "all the time" (score = 4). The total score is the sum of the items and its range is from 0 to 52, higher scores are associated with higher levels of pain catastrophizing. This scale was used to assess the degree of pain catastrophizing in patients, and the Cronbach's α coefficient for this scale in this study was 0.899.

Numerical Rating Scale

NRS is a tool for patients to assess their pain intensity. It consists of numbers from 0–10, and higher numbers represent more severe pain.¹³ In this study, this scale was used to assess the level of acute post-surgical pain in patients with KA.

In our study, knee functional exercises were chosen as the benchmark activity for evaluating acute post-surgical pain assessment after knee arthroplasty surgery. The average of the pain scores of T2, T3, and T4 were taken as the score of acute post-surgical pain. A score of ≥ 4 was considered as the presence of acute post-surgical pain.

Analytic Approach

In this study, Data analysis was conducted by the researcher using the statistical software SPSS 25.0. Initially, descriptive analyses were conducted to report the characteristics of the sample (continuous variables: means and standard deviations; categorical variables: frequencies and percentages). Additionally, t-tests or ANOVA were used to explore the association between sample characteristics and acute post-surgical pain. Pearson correlation analysis was used to examine the correlation between the three variables: social support, pain catastrophizing, and acute post-surgical pain. Finally, moderated effects were tested using stratified regression analyses. Level 1: Variables that affected acute post-surgical pain were used as control variables in regression analyses; Level 2: Pain catastrophizing and social support were selected into the regression equation; Level 3: The interaction term between pain catastrophizing and social support was selected into the regression equation. A significance level of $P < 0.05$ was used to determine statistical differences.

Results

Sample Characteristics

The study included 178 patients who underwent knee arthroplasty. The average age of the participants was 68.38 years, with a standard deviation of 6.66 years. 78.65% of patients were female. 53.93% of the patients were between 60–69 years old; 43.82% of patients had a BMI ≥ 28 ; 86.52% of patients were married; 79.21% of patients had completed junior

high school education or below; 53.93% of patients were farmers; 52.81% of patients lived in the urban; 50.56% of the patients paid by rural cooperative medical insurance; 64.61% of patients had knee osteoarthritis for more than 5 years; 64.04% of patients had comorbidities before operations; 87.27% of patients were able to walk on their own; 76.96% of the patients had knee arthroplasty surgery for the first time; 98.88% of the surgeries were knee surface arthroplasty. Additionally, 68.54% of participants had an operation time of more than 120 minutes. Severe preoperative pain was self-reported in 48.31% of participants.

The results of the *t*-test or one-way ANOVA indicated that gender, age, education, occupation, disease duration, whether the knee replacement was performed for the first time, preoperative pain scores, and operation time were statistically significant ($P < 0.05$) in the context of acute post-surgical pain in patients who underwent knee arthroplasty. The relevant socio-demographic data and relevant clinical and therapeutic information about the disease are shown in Table 1.

Table 1 Comparison of Scores for Socio-Demographic Information and Relevant Clinical and Therapeutic Information (N=178)

		n	%	The Score of Acute Post-Surgical Pain (Mean±SD)	t/F
Gender	Male	38	21.35	6.49±2.17	2.219*
	Female	140	78.65	7.27±1.86	
Age	50–59	11	6.18	7.91±2.26	4.113*
	60–69	96	53.93	7.42±1.92	
	70–79	61	34.27	6.68±1.69	
	80–89	10	5.62	5.80±2.45	
BMI	<18.5	2	1.12	6.67±0.00	0.539
	18.5–23.9	25	14.04	7.33±1.82	
	24–27.9	73	41.02	7.25±2.09	
	≥28	78	43.82	6.91±1.88	
Ethnic group	Han	169	94.94	7.07±1.94	1.120
	Others	9	5.06	7.82±2.11	
Material status	Married	154	86.52	7.10±1.93	0.086
	Others	24	13.48	7.14±2.13	
Education	Junior high school or lower	141	79.21	7.29±0.16	2.529*
Education	Senior high school or higher	37	20.79	6.40±1.91	
Occupation	Famer	96	53.93	7.07±1.78	9.340*
	Worker	77	43.26	7.38±2.00	
	Self-employed	5	2.81	3.67±0.75	
Place of residence	Rural	84	47.19	7.11±1.80	0.003
	Urban	94	52.81	7.11±2.08	
Insurance type	Rural cooperative medical insurance	90	50.56	7.13±0.19	0.159
	Urban resident's basic medical insurance	88	49.44	7.08±0.23	

(Continued)

Table 1 (Continued).

		n	%	The Score of Acute Post-Surgical Pain (Mean±SD)	t/F
Disease duration	<1	13	7.30	8.97±1.11	7.758*
	1–5	50	28.09	7.25±2.11	
	>5	115	64.61	6.83±1.84	
Comorbidities	No	64	35.96	6.97±1.94	1.297
	Yes	114	64.04	7.36±1.95	
Preoperative walking status	Walk on one's own	150	84.27	7.02±2.00	1.448
	Auxiliary	28	15.73	7.60±1.60	
Whether the knee arthroplasty was the first time	Yes	137	76.96	7.27±1.96	1.996*
	No	41	23.04	6.58±1.84	
Type of operation	Unicondylar arthroplasty	2	1.12	7.10±1.96	0.406
	Knee surface arthroplasty	176	98.88	7.67±0.47	
Operation time	60–120min	56	31.46	6.58±2.06	2.489*
	>120min	122	68.54	7.35±1.85	
Preoperative pain scores	0–3	10	5.62	5.53±2.34	5.377*
	4–6	82	46.07	6.92±1.89	
	7–10	86	48.31	7.47±1.86	

Notes: * $P < 0.05$.

Abbreviation: BMI, body mass index.

Descriptive Analysis and Correlation Between Social Support, Pain Catastrophizing, and Acute Post-Surgical Pain

The average of acute post-surgical pain score was 7.11 ± 1.95 , and the highest percentage ($n=167$, 93.8%) of acute post-surgical pain was reported. Preoperative pain catastrophizing was present in 62.40% of participants, and the average of pain catastrophizing score was 36.33 ± 9.51 . The average of social support score was 38.53 ± 6.64 . The descriptive characteristics of these three variables are shown in Table 2.

Social support was negatively associated with acute post-surgical pain ($r=-0.584$, $P<0.01$), and pain catastrophizing was positively related to acute post-surgical pain ($r=0.601$, $P<0.01$).

Analysis of Moderating Effects

Analysis of moderating effects revealed that social support can influence the impact of pain catastrophizing on acute post-surgical pain. The examination was conducted in three levels. Level 1: Variables that affected acute post-surgical pain were used as control variables in regression analyses; Level 2: Pain catastrophizing and social support were selected into the regression equation; Level 3: The interaction term between pain catastrophizing and social support was selected into the regression equation. the coefficient of the interaction term between social support and pain catastrophizing was significant ($\beta = -0.113$, $P < 0.05$), and the adjusted R^2 was enhanced from 0.598 to 0.606. Thus, social support acted as a moderating factor between pain catastrophizing and acute post-surgical pain. The results are shown in Table 3.

Table 2 Descriptive Analytical Statistics and Correlations Between Social Support, Pain Catastrophizing, and Acute Post-Surgical Pain (N=178)

Variable	Mean±SD	Social Support	Pain Catastrophizing	Acute Post-surgical Pain
Social Support	38.53±6.64	I		
Pain Catastrophizing	36.33±9.51	−0.287**	I	
Acute Post-surgical Pain	7.11±1.95	−0.584**	0.601**	I

Notes: **P< 0.01.

Table 3 Moderating Results of Social Support Between Pain Catastrophizing and Acute Post-Surgical Pain (N=178)

Variable	M1	M2	M3
Gender	0.108	−0.032	−0.013
Age	−0.182*	−0.145**	−0.143**
Education attainment	−0.089	−0.045	−0.052
Occupation	0.014	0.052	0.027
Disease duration	−0.165*	−0.027	−0.025
Whether the knee arthroplasty was the first time	−0.103	−0.079	−0.073
Preoperative pain scores	0.182*	0.141**	0.140**
Operation time	0.174*	0.153**	0.148**
Pain Catastrophizing		0.418**	0.460**
Social Support		−0.436**	−0.427**
Pain Catastrophizing Social Support			−0.113*
R ²	0.211	0.621	0.631
ΔR ²	0.174	0.598	0.606
F	5.657**	27.372**	25.756*

Notes: *P< 0.05, **P< 0.01.

Discussion

In the study, the percentage of acute pain after knee arthroplasty was found to be 93.8%, which is similar to the results of previous studies.²² However, it is significantly higher than that in Wylde’s²³ study. In this study, The cause of this disparity may be attributed to the fact that post-surgical pain assessment was functional limb exercises, and the intensity of pain was more severe in the active state than in the resting state in surgical patients.²⁴ It is widely acknowledged that early postoperative functional exercises are beneficial for promoting knee joint muscle strength and mobility, which in turn facilitates the rehabilitation process for patients following surgery, and the occurrence of acute post-surgical pain affects the progress of postoperative functional exercises.²⁵ The occurrence of acute post-surgical pain in knee arthroplasty is also an independent risk factor for persistent pain 1 year after surgery.²⁶ Therefore, controlling acute post-surgical pain after knee arthroplasty is crucial.

The occurrence of acute pain after knee arthroplasty has an impact on patient’s quality of life.²⁷ The results of the current study showed that gender, age, education, occupation, disease duration, whether the knee replacement was performed for the first time, preoperative pain scores, and operation time were the factors influencing acute post-surgical pain after knee arthroplasty. The results of this study showed that female patients reported higher levels of pain than male patients, which is consistent with the findings of Siviero.²⁸ It may be due to the fact that as knee Osteoarthritis

progresses, female patients have limb deformity and degeneration of the articular cartilage, but male patients have not the same symptoms, the poorer condition of the knee joint in female patients may be the reason for the higher acute pain scores after surgery.²⁹ With increasing age, the body gets older and estrogen levels decrease, reducing the body's sensitivity to painful stimuli, thus the older patient has a lower level of acute post-surgical pain.³⁰ The patients with a higher level of education have a lower level of acute post-surgical pain. The main reason is that patients with different levels of education have different perceptions of pain. Patients with lower levels of education think the pain is a hurtful signal and uncontrollable, so they are unable to manage pain effectively.³¹ Occupation is also an influential factor in acute post-surgical pain. It may be related to differences in income.³² Patients with longer disease duration had lower levels of acute post-surgical pain. It's similar to the findings of Kong Weiwei.¹⁷ It may be explained by the fact that patients with longer duration of the disease suffer from pain for longer time, which increases the pain threshold, so it resulted in a lower level of acute post-surgical pain.

Patients with primary knee arthroplasty reported higher levels of pain contrary to the findings of Puolakka's³³ study, which may be influenced by socio-demographic differences in sample size, culture, etc. in the various studies. The reason why patients with higher levels of preoperative pain have higher levels of acute post-surgical pain is that patients with more severe preoperative lesions in knee osteoarthritis have higher levels of pain, they have higher expectations in surgical operation, the excessive expectation has a negative impact on the patient's health status in the post-surgical period.³⁴ Operation time was a risk factor for acute post-surgical pain. Because tourniquets were used during knee arthroplasty, the longer operation time, the longer the tourniquet was used, which increased the swelling of the patient's surgical site and affected the mobility of the knee joint. So it increased the level of acute post-surgical pain.²² This suggests that patients with knee arthroplasty who are female, younger, less educated, type of occupation, shorter duration of disease, first-time knee arthroplasty, higher preoperative pain scores, and longer operation time should be focused.

In this study, we found a negative correlation between social support and acute post-surgical pain in knee arthroplasty patients, which is similar to the findings of Baorong Xie et al.³⁵ Patients with higher social support scores mean that they have more social resources from family, friends, etc. When they experience pain, family, friends, and other social resources can provide timely consolation, they will feel that their pain is understood and accepted, and they are likely to express their pain and correctly face the post-surgical pain. Therefore the pain can be relieved in time.²⁷

The study indicated that pain catastrophizing was positively correlated with acute post-surgical pain, which is consistent with previous studies.³⁶ This finding suggests that individuals with higher preoperative pain catastrophizing levels experience higher levels of acute post-surgical pain. The potential explanation for this study is that pain catastrophizing, as a negative psychological emotion, amplifies the patient's subjective sense of pain. It can make patients lack the enthusiasm to face pain. As a result, individuals with higher pain catastrophizing experience higher levels of pain.³⁷ Additionally, patients with higher levels of pain catastrophizing are more likely to be biased toward central sensitization,³⁸ which is associated with increased pain sensitivity. Consequently, individuals with central sensitization are more susceptible to pain and are unable to alleviate it effectively. This may also be one of the reasons why patients with higher levels of pain catastrophizing have higher levels of acute post-surgical pain.^{39,40} Previous research has indicated that preoperative pain catastrophizing influences pain levels at various time points after knee arthroplasty, including 6 weeks, 6 months, 1 year, and 21 months postoperatively.^{37,41–43} Consequently, it is crucial to identify patients with preoperative pain catastrophizing, and measures should be taken to reduce the impact on acute post-surgical pain in knee arthroplasty patients.

In addition, our study also indicated that social support serves as a moderating role between pain catastrophizing and acute post-surgical pain. When patients have the same level of pain catastrophizing, patients who have higher levels of social support are likely to have lower levels of acute post-surgical pain than those with lower levels of social support. Social support refers to the material and moral assistance that an individual can obtain from others, and it represents an external resource that can be utilized in terms of need.¹² Social support can protect individuals under pain stress, and buffer the stressful effects of pain. Higher social support can give patients emotional support, making them feel less helpless to cope with pain and reducing negative emotional states.⁴⁴ On the other hand, higher levels of social support enable patients to receive more support and help them make decisions in coping with pain, it also increases patients' positive behaviors, helps patients to develop positive coping strategies for pain, and reduces pain levels.⁴⁵ Pain catastrophizing is stable and it does not change over time.⁴⁶ However Social support can be improved through psychological, emotional, and cognitive interventions, while meditation training and

peer education can improve the level of social support of patients.^{47,48} Therefore, we should pay more attention to the patients with preoperative pain catastrophizing thoughts in clinical nursing. We should focus on their level of social support, and provide targeted health education for patients to improve their social support according to the actual situation, which can make them have more positive psychological responses to acute post-surgical pain, and help them better face the disease. They can reduce the impact of pain catastrophizing thoughts on acute post-surgical pain, and reduce the acute post-surgical pain.

There were also some shortcomings in our study. Firstly, in this study, the participants were sourced from only one hospital, which is geographically homogenous and the data may lack adequate representation. Secondly, our study was limited to identifying associations between variables, the participants were not randomly assigned to specific conditions. Additionally, the acute post-surgical pain was assessed only for 72 hours postoperatively, which was a short assessment period. So the results of the study may be biased. In the future, we will conduct a multi-center, large-sample study to explore the correlation among the social support, pain catastrophizing, and acute post-surgical pain. At the same time, long-term follow-up of patients with knee arthroplasty will be conducted, and intervening variables will be introduced to more effectively explain the moderating role of social support in patients with knee arthroplasty between pain catastrophizing and acute post-surgical pain.

Conclusion

In this study, we investigated pain catastrophizing and acute post-surgical pain in knee arthroplasty patients through a moderating effects model: the moderating role of social support. The acute post-surgical pain of knee arthroplasty patients was affected by gender, age, education, occupation, disease duration, whether the knee arthroplasty was performed for the first time, preoperative pain scores, and operation time. Postoperative acute pain in patients with knee arthroplasty was affected by social support and pain catastrophizing, and social support had a moderating effect on the relationship between pain catastrophizing and acute post-surgical pain.

Ethics Statement

The study complied with the principles outlined in the Declaration of Helsinki and was also approved by the Ethics Committee of the First Hospital of Dalian Medical University (PJ-KS-KY-2023-40). All participants signed an informed consent form before participating in this study.

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Disclosure

The authors report no conflicts of interest in this work.

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