ORIGINAL RESEARCH

Patient-Reported Quality of Life Before and After Total Knee Arthroplasty: A Multicenter Observational Study

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Purpose: To compare patients' self-reported health-related quality of life (HRQoL) before and after total knee arthroplasty (TKA) and determine factors contributing to any heterogeneity in HRQoL.

Patients and Methods: This prospective multicenter observational study included 404 patients with knee osteoarthritis who underwent TKA between April 1, 2019 and December 30, 2019 and whose HRQoL was assessed preoperatively and 7 days and 1, 3, and 6 months postoperatively. Sociodemographic characteristics were assessed using a General Information Questionnaire, disability using the Knee Injury and Osteoarthritis Outcome Score (KOOS-PS), resting pain using the visual analogue scale (Pain-VAS), and HRQoL using the European Quality of Life Five Dimension Five Level (EQ-5D-5L) scale. The growth mixture model was used to identify group heterogeneity in the developmental trajectories of KOOS-PS, Pain-VAS, and EQ5D5L. Logistic regression was used to explore the factors influencing the developmental trajectories of factors affecting the developmental trajectory of HRQoL.

Results: The mean EQ-5D-5L score improved from 0.69 preoperatively to 0.90 at 6 months postoperatively. Longitudinal heterogeneity in HRQoL was observed in patients during recovery: 1) patients with a small and slow improvement in HRQoL and 2) patients who showed marked and rapid improvement in HRQoL. The main characteristics of the latter group were decreasing VAS pain scores, a monthly family income >2000 CNY (100 CNY equals approximately 14.9 USD), exercising for <30 min daily, and better knee function at baseline. Baseline knee function and change in knee function were significantly associated with the percentage change in HRQoL.

Conclusion: HRQoL improved considerably after TKA. However, there was heterogeneity in the changes in HRQoL depending on patients' socioeconomic status, exercise, and baseline knee function. Dynamic tracking of the HRQoL of TKA patients and timely provision of rehabilitation guidance will promote continuous improvement of the HRQoL of TKA patients.

Keywords: knee osteoarthritis, knee replacement, knee function

Introduction

Osteoarthritis is a common chronic musculoskeletal disease that affects nearly 400 million people worldwide and imposes a heavy socioeconomic burden on individuals and health care systems in many countries.[1–3] Knee osteoarthritis (KOA) is present in 86.8% of osteoarthritis cases and is the main cause of knee pain.[2,4] It is characterized by the destruction of the articular cartilage of the knee and osteophyte formation. Patients with KOA often have reduced self-care ability and even disability due to joint pain, stiffness, and limited activity, which have an increasingly severe impact on their quality of life and leads to a wide range of social problems over time.[3]

The prevalence of KOA in the Chinese population over the age of 40 years is reported to be 17.0%, affecting 12.3% of men and 22.2% of women, and both these figures are higher than the world average values.[5] Furthermore, the

proportion of younger patients with KOA is increasing, and it is projected that the proportion of the population over the age of 45 years with a diagnosis of KOA will increase from 13.8% to 15.7% by 2032.[6,7] This degenerative disease adversely affects the health-related quality of life (HRQoL) of middle-aged and older patients and represents a substantial burden of disease in China.

Total knee arthroplasty (TKA) is the most effective treatment for end-stage KOA[8–11] and has been performed for over 40 years.[12,13] Previous studies have shown that 80–85% of patients with KOA have good outcomes after TKA.[14–16] However, several studies have reported that not all patients are satisfied with the outcome after surgery, with 15–20% of patients reporting persistent pain, poor joint function, and postoperative infection, among other complications, warranting a need for revision surgery.[17]

Previous studies of TKA have focused primarily on the clinical effectiveness of the surgery and its risk factors,[18,19] costs versus benefits of surgery,[20] or the safety and efficacy of postoperative rehabilitation.[21] Although some studies have investigated HRQoL of patients after TKA,[22,23] the factors affecting changes in HRQoL are not clear. The Growth Mixture Model (GMM) has the advantage of being able to identify different growth trajectories of unobservable subgroups in longitudinal data analysis (eg, Figures S1 and S2) and thus provides insights into the development of individuals using longitudinal data; this makes this model very suitable for the analysis of the follow-up evaluation of the HRQoL of patients with KOA. The specific process for fitting GMM is described in the Trajectory Analysis section of the Supplementary Materials.
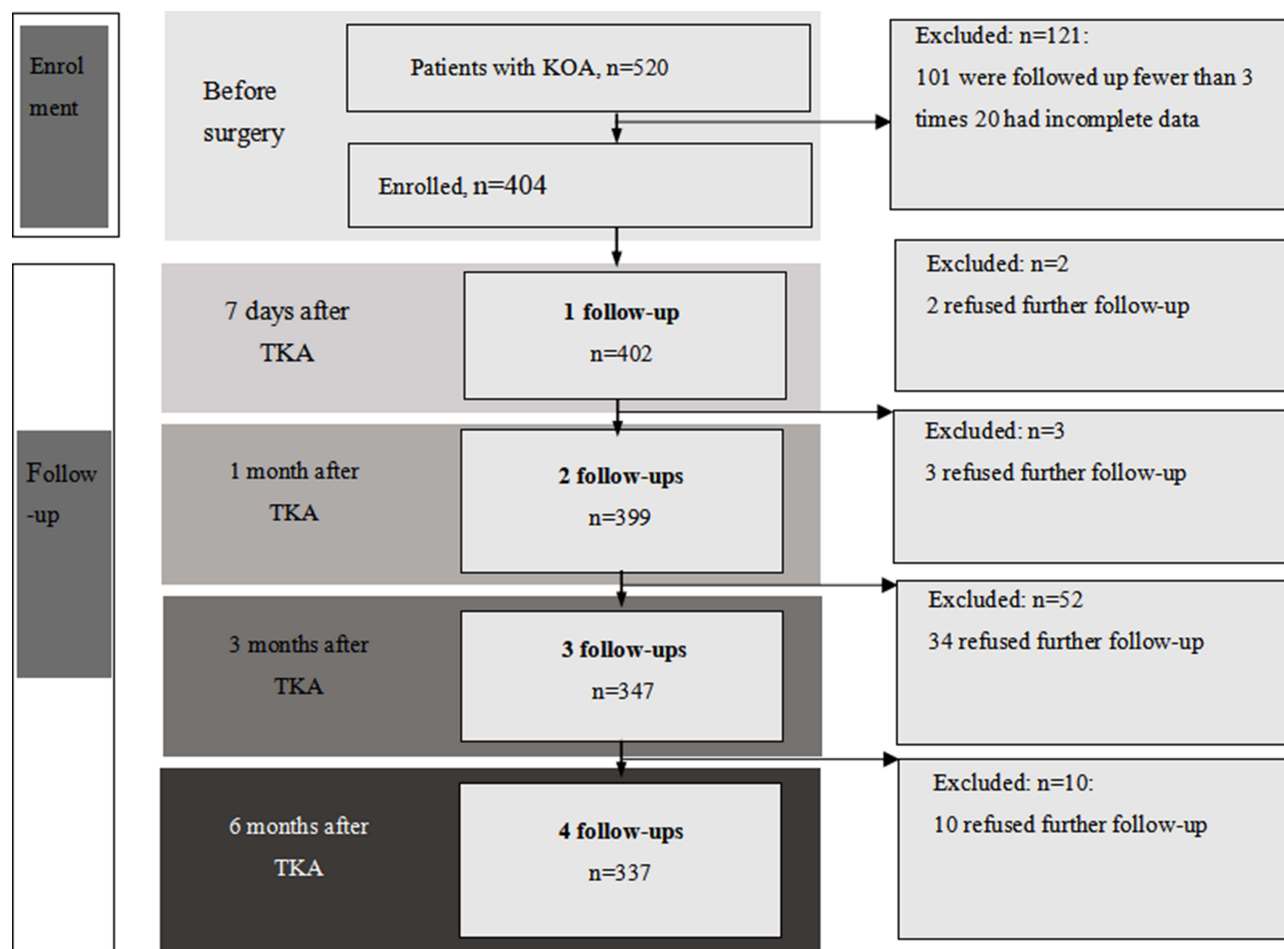

Figure 1 Flow chart showing the study screening and enrolment process.
Abbreviations: KOA, knee osteoarthritis; TKA, total knee arthroplasty.

Therefore, we conducted this multicenter observational study in Guangzhou, the largest city in Southern China, to assess the self-reported HRQoL trajectories of patients with KOA before and after TKA and to identify the factors contributing to any differences observed in these trajectories.

Materials and Methods

Study Design and Participants

This prospective observational study enrolled patients who underwent TKA at one of four tertiary hospitals in four districts in Guangzhou, China, between April 1, 2019 and December 30, 2019. The following inclusion criteria were used: 1) diagnosis of KOA based on the 2018 clinical guidelines for the diagnosis of osteoarthritis in China,[24] 2) first TKA procedure, 3) willingness and ability to complete questionnaires, and 4) completion of at least three of five follow-up questionnaires. Patients with a psychiatric disorder, those with serious comorbidities (eg malignant tumors, post-stroke state, end-stage renal disease, severe Parkinson's disease), and those who were not independently self-caring were excluded. Questionnaires were distributed to patients by the investigators and medical students at the five assessment points. In total, 404 of 520 patients with KOA screened at baseline met the study inclusion criteria and attended at least three follow-up visits. The screening process and follow-up of patients throughout the study are shown in Figure 1. This study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology statement for the reporting of observational studies.

Ethics

The study was approved by the Ethics Committee of the Third Affiliated Hospital of Southern Medical University (approval number 2018-IORG-10-1) and performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all study participants.

General Information Questionnaire

Sociodemographic characteristics were obtained from a questionnaire adapted from the General Information Questionnaire developed by the International Consortium for Health Outcomes Measurement for KOA. Information collected included that on sex, age, marital status, education level, weight, height, monthly family income, basic health insurance, smoking status, alcohol consumption, frequency of physical activity, history of KOA, and history of knee surgery. Body mass index (BMI, in kg/m^2) was calculated for each patient. Using the BMI cut-off values reported for the Chinese population, patients were classified as follows: underweight (<18.5), normal weight (18.5–23.9), overweight (24.0–27.9), and obese (≥28).[25]

Knee Injury and Osteoarthritis Outcome Score

The Knee Injury and Osteoarthritis Outcome Score (KOOS-PS) is a short version of the original KOOS. It is a self-administered instrument that measures the outcomes of impairment, disability, and handicap after knee injury and comprises seven dimensions, each of which is scored from 0 to 4 for the degree of difficulty (0, none; 1, slight; 2, moderate; 3, very; and 4, extreme). The original total score ranges from 0 to 28, with a higher score indicating better joint function.[26] The KOOS-PS standard score is obtained by converting the score formula specified by the scale and ranges from 0 to 100.[13]

Visual Analogue Pain Scale

Patients' subjective perception of resting pain was estimated using the visual analogue scale (VAS) score, which is widely used and determined by measuring the distance on a 10-cm line between the "no pain" anchor and mark made by the patient. Patients use a vertical line to mark their current level of knee pain. Scores range from 0 to 10, and a higher score indicates greater pain intensity.

European Quality of Life Five Dimension Five Level Scale

The European Quality of Life Five Dimension Five Level (EQ-5D-5L) scale is a standardized instrument developed by the EuroQol group to measure health status and is widely used internationally.[27] It comprises five dimensions (mobility,

Table I Reliability of KOOS-PS and EQ-5D-5L Scores at Five Time Points from Before Surgery to 6 Months After Surgery

Variable	Before Surgery	7 Days After TKA	I Month After TKA	3 Months After TKA	6 Months After TKA
KOOS-PS score					
Cronbach's alpha	0.85	0.83	0.81	0.81	0.80
EQ-5D-5L score					
Cronbach's alpha	0.77	0.78	0.72	0.79	0.79

Abbreviations: EQ-5D-5L, European Quality of Life Five Dimension Five Level; KOOS-PS, Knee Injury and Osteoarthritis Outcome Score; TKA, total knee arthroplasty.

self-care, usual activities, pain/discomfort, and anxiety/depression), each of which is rated on a 5-point scale (none, not difficult; slight, a little difficult; moderate, some difficulty; severe, very difficult; or extreme, impossible). The scores obtained were converted into a total score using the Chinese scoring system and ranged from −0.391 to 1.000, with higher scores representing a better health status.[28]

Reliability

Internal consistency was measured using the Cronbach's alpha coefficient. An alpha value between 0.70 and 0.95 was considered to indicate acceptable reliability. Cronbach's coefficients for the five measurements of the KOOS-PS scale and five measurements of the EQ-5D-5L scale are listed in Table 1.

Statistical Analysis

Continuous variables are summarized as mean and standard deviation, and categorical variables are shown as frequency (percentage). Categorical variables were compared using Pearson's test, and continuous variables were compared using Student's t-test or the Wilcoxon test. Statistical significance was set at a p-value < 0.05. Spearman correlation coefficient was used to describe the correlation between the KOOS-PS and EQ-5D-5L scores at each time point. The GMMs were fitted in a two-step approach to identify potential heterogeneity of KOOS-PS, VAS, and EQ-5D-5L, where factor loadings of the slope terms as well as variances and covariances of continuous latent variables were free estimates across groups. First, two unconditional GMMs were fitted to KOOS-PS and VAS, respectively. Next, a conditional GMM was fitted to the EQ-5D-5L score, where KOOS-PS_I (the intercept term of KOOS-PS), KOOS-PS_S (the slope term of KOOS-PS), and VAS_C (the categorical latent variable of VAS) from the first step were entered as covariables. The categorical latent variables of the EQ-5D-5L were used as the grouping variables. Univariable and multivariable logistic regression models were used to explore the factors associated with the EQ-5D-5L score. The multivariable logistic regression model was established by including variables with a p-value < 0.1. Monthly family income, exercise, KOOS-PS_I, KOOS-PS_S, and VAS_C were independent variables, and EQ-5D-5L_C was the dependent variable. VAS_C and EQ-5D-5L_C represented categorical latent variables. R 3.6.2 was used for data cleaning, statistical description, and regression analysis, and Mplus 8.3 software was used for the GMM analysis.

Results
Patient Characteristics

The patient characteristics are presented in Table 2. Of the 404 study participants, 313 (77.48%) were women, 395 (97.77%) were over the age of 40 years, 396 (98.2%) were married, and 221 (55.22%) had not been educated beyond the elementary School level. Monthly family income was < 2000 CNY for 198 (49.75%), 2000–4000 CNY for 106 (26.63%), and > 4000 CNY for 94 (23.62%) patients. A total of 141 patients (34.90%) did not exercise daily, 106 (26.24%) exercised for < 30 min daily, and 157 (38.86%) exercised for > 30 min daily. A total of 289 (71.53%) patients were overweight or obese.

Changes in EQ-5D-5L and KOOS-PS Across Five Time Periods

Table 3 shows the changes in HRQoL and knee function over time, as assessed using the EQ-5D-5L and KOOS-PS scores. In comparison with preoperative values, HRQoL and knee function scores were lower on postoperative day 7 but

Table 2 Patients' Demographic and Clinical Characteristics (n=404)

Variable	Classification	n (%)
Location	Hospital A	116 (28.71)
	Hospital B	71 (17.57)
	Hospital C	197 (48.76)
	Hospital D	20 (4.95)
Sex	Male	91 (22.53)
	Female	313 (77.48)
Age, years	<60	90 (22.28)
	60–74	242 (59.90)
	>74	72 (17.82)
Marital status	Unmarried	8 (1.98)
	Married	396 (98.02)
Education	Elementary school or below	221 (55.11)
	Junior high school	91 (22.69)
	Junior college or high school	49 (12.22)
	College/bachelor or above	40 (9.98)
Smoker	No	378 (93.56)
	Yes	26 (6.44)
Alcohol consumption	No	385 (95.30)
	Yes	19 (4.70)
Monthly family income, CNY [USD]	<2000*	198 (49.75)
	2000–4000	106 (26.63)
	>4000	94 (23.62)
Medical insurance	No	32 (7.92)
	Yes	372 (92.08)
Duration of illness, years	<5	174 (43.07)
	6–15	174 (43.07)
	>15	56 (13.86)
Expected duration of recovery, months	<1	350 (86.63)
	≥1	54 (13.37)
Hospital stay, days	<5	27 (6.72)
	6–8	118 (29.35)
	9–11	119 (29.60)
	>11	138 (34.33)
Daily exercise, minutes	None	141 (34.90)
	<30	106 (26.24)
	≥30	157 (38.86)
Body mass index	<18.5	5 (1.24)
	18.5–24	110 (27.23)
	24–28	164 (40.59)
	>28	125 (30.94)

Notes: 100 CNY equals approximately 14.9 USD (April 2019 exchange rate). *100 CNY ¥ equals approximately 14.9 US $ (April, 2019 exchange rate).

Table 3 EQ-5D-5L and KOOS-PS Mean Scores at Five Time Points from Before Surgery to 6 Months After Surgery

Variable	Before TKA	7 Days After TKA	1 Month After TKA	3 Months After TKA	6 Months After TKA
KOOS-PS					
Mean±SD	65.774±15.02	59.627±13.03	67.046±12.46	72.925±11.47	76.984±10.82
EQ-5D-5L					
Mean±SD	0.686±0.23	0.625±0.26	0.768±0.21	0.858±0.17	0.895±0.14

Note: Data are shown as mean±SD.
Abbreviations: EQ-5D-5L, European Quality of Life Five Dimension Five Level; KOOS-PS, Knee Injury and Osteoarthritis Outcome Score; TKA, total knee arthroplasty; SD, standard deviation.
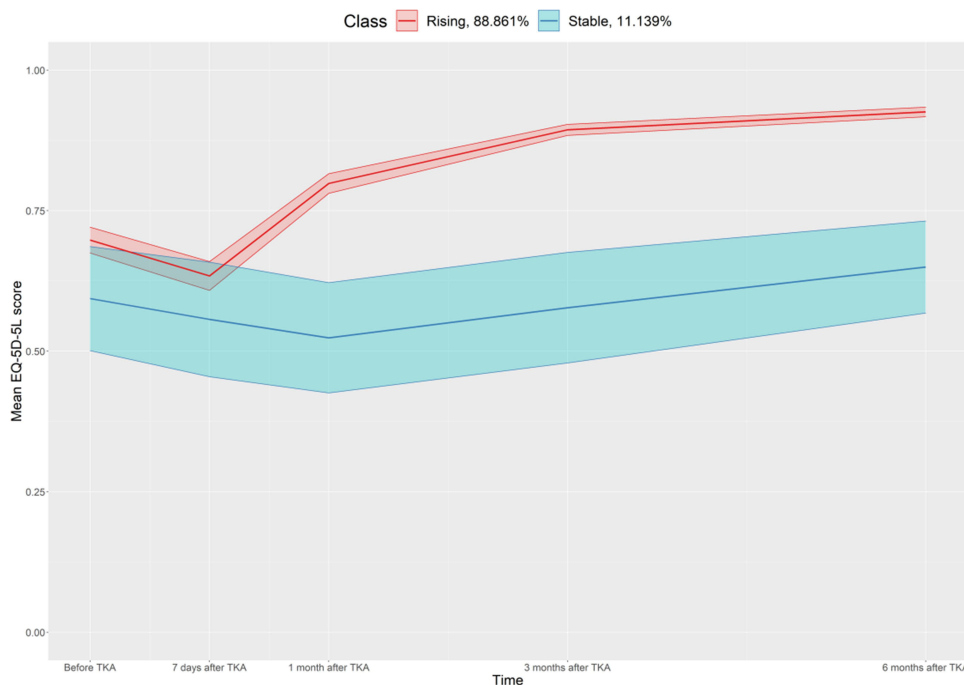
Figure 2 Average health-related quality of life trajectory based on the EQ-5D-5L score in a 2-class growth mixture model.
Abbreviations: EQ-5D-5L, European Quality of Life Five Dimension Five Level; TKA, total knee arthroplasty.

improved significantly by 6 months after surgery. There was a significant correlation between the KOOS-PS score and the EQ-5D-5L score before surgery; at 7 days; and at 1, 3, and 6 months after surgery, with Spearman correlation coefficients of 0.568, 0.654, 0.579, 0.525, and 0.538 (p<0.001), respectively.

Selection of the Best GMM

KOOS-PS, VAS, and EQ-5D-5L scores did not show linear or quadratic growth trajectories over time (Figures S3–S5); therefore, GMMs were fitted in a two-step approach to identify potential heterogeneity of KOOS-PS, VAS, and EQ-5D-5L, where factor loadings of the slope terms as well as variances and covariances of continuous latent variables were free estimates across groups. First, two unconditional GMMs were fitted to KOOS-PS and VAS, respectively. The model fitting results (Tables S1 and S2) showed that the best classifications for KOOS-PS and VAS pain scores were 1 class (latent growth curve modeling) and 2 class, respectively. Next, a conditional GMM was fitted to the EQ-5D-5L score, where KOOS-PS_I (the intercept term of KOOS-PS), KOOS-PS_S (the slope term of KOOS-PS), and VAS_C (the categorical latent variable of VAS) from the first step were entered as covariables.[29–31] According to Table S3, the 2-class GMM was deemed to be the best fitting model for representing the HRQoL trajectories over five time periods. The individual growth trajectories of these two classes are shown in Figures S6 and S7. The average trajectory of the 2-class GMM-C is shown in Figure 2. Patients in whom the average HRQoL trajectory (EQ-5D-5L) improved markedly and rapidly after TKA were classified as the "rising" group, and those in whom the increase in the HRQoL trajectory was slower and less marked were classified as the "stable" group.

Parameter Estimates of HRQoL in the 2-Class GMM

Table S4 presents the parameter estimates for the selected 2-class GMM of the EQ-5D-5L scores. In the stable group (n = 45), the baseline EQ-5D-5L scores (EQ-5D-5L_I) were positively associated with the baseline KOOS-PS scores (KOOS-PS_I) (β = 0.021, p < 0.001). The results of the heterogeneity analysis in the stable group also showed that there were differences in the baseline HRQoL scores among individuals (residual mean-0.446, p = 0.044 and residual variance, −0.023, p = 0.014), although there were no significant differences in the change in HRQoL among individuals (p = 0.569 and p = 0.742). The intercept was not correlated with the slope (p = 0.972). In the rising group (n = 359), the

baseline EQ-5D-5L (EQ-5D-5L_I) score (β= 0.030, p < 0.001) was positively associated with the baseline KOOS-PS score (KOOS-PS_I). However, KOOS-PS_I was negatively associated with the rate of change in EQ-5D-5L (EQ-5D-5L_S; β=−0.015, p < 0.0001). The residual differences in the initial HRQoL scores among individuals were significant (p < 0.001), as was the rate of change (p < 0.001).

Latent HRQoL Variables as Risk Factors

In univariable analysis, the KOOS-PS knee function score, monthly family income, amount of daily exercise, and VAS_C were associated with being in the rising EQ-5D-5L group (p<0.1) (Table 4). In the multivariable logistic regression model (Table 5), compared with that of patients with a monthly family income < 2000 CNY, the odds of being in the rising group was higher for patients with a monthly family income of 2000–4000 CNY (odds ratio [OR] 6.19, 95% confidence interval [CI] 2.16–21.57) and > 4000 CNY (OR 19.73, 95% CI 3.77–366.69). The odds of being in the rising group were higher for patients who exercised for < 30 min daily than for those who did not (OR 2.95, 95% CI 1.06–9.02). However, when daily exercise was performed for > 30 min, the odds were not significant (OR 1.62, 95% CI 0.66–4.02), considering patients who did not exercise as reference. For patients with a decreasing VAS pain score, the odds of being in the rising group were higher than for those with a stable VAS pain score (OR 6.09, 95% CI 2.72–14.07). Compared with that with the preoperative KOOS-PS score, we also found that the odds of being in the rising group increased with higher KOOS-PS scores (Table 5).

Discussion

This study aimed to identify any population heterogeneity in factors influencing changes in the HRQoL of patients with KOA that can be used to develop individualized treatment strategies.

We found that patients showed improvement in knee function and HRQoL after TKA, which is consistent with the findings of Zhang et al [32] and Neuprez et al.[33] The trajectory for EQ-5D-5L indicated that patients experienced a cycle of change in knee function and HRQoL after TKA. HRQoL would be expected to deteriorate for a short period immediately after TKA owing to postoperative bed rest, limited knee function, and wound pain. Osteotomy, unicompartmental knee arthroplasty, TKA, and arthroscopic surgery can all improve functional scores of patients with KOA; however, follow-up studies indicate that TKA is better than other interventions in terms of relieving knee pain and improving knee function in the long term.[34] HRQoL is not only an indicator of physical fitness but also a reflection of the psychological and socioeconomic status. Therefore, mental well-being may be almost as important as physical discomfort and activity restriction in determining self-reported outcomes and HRQoL after TKA.[35,36] High preoperative expectations are associated with clinical improvement, including pain reduction.[37] Maintaining a stable emotional state and a positive attitude toward short-term discomfort are important for patients undergoing TKA. Additionally, patients should follow medical advice strictly and adhere to examinations, treatment, and rehabilitation exercises. Doctors and rehabilitation therapists should strengthen preoperative communication and psychological counseling for these patients. Appropriate guidance and care are essential to gain the full trust of patients with KOA and to boost their confidence, which is essential for the success of the treatment.[38]

In this study, the results of 2-class GMM indicate that higher the baseline knee function score, the more rapid the improvement in knee function and HRQoL after surgery. This finding suggests that patients with better knee function at baseline would derive maximum benefit from surgery, which is consistent with the findings of Fortin et al.[39] Age-related neuromotor changes lead to skeletal muscle weakness and reduced power. Muscle strength and power have been reported to decrease by at least 24% in TKA recipients compared with controls.[40] However, more demanding rehabilitation protocols may help overcome these deficits. Postoperative rehabilitation following TKA would make a substantial contribution to patient outcomes, including a shorter hospital stay and fewer complications. Early rehabilitation, telerehabilitation, outpatient therapy, and high intensity and high velocity exercise may be beneficial to reduce pain intensity and joint stiffness.[39] Therefore, joint rehabilitation training and functional exercises should be initiated under medical supervision as soon as possible for these patients. An improved focus on patient rehabilitation after discharge, including home-based exercise and dietary guidance, may also be needed to maximize the benefits of surgery.[41]

Table 4 Comparison of Sociodemographic Characteristics Between the Stable and Rising Groups

Variable	Classification	Rising Group (n=359)	Stable Group (n=45)	p-value
Location, n (%)	Hospital A	102 (87.93)	14 (12.07)	0.167
	Hospital B	66 (92.96)	5 (7.04)	
	Hospital C	176 (89.34)	21 (10.66)	
	Hospital D	15 (75)	5 (25)	
Sex, n (%)	Male	82 (90.11)	9 (9.89)	0.667
	Female	277 (88.50)	36 (11.50)	
Age, years, n (%)	<60	81 (90)	9 (10)	0.703
	60–74	216 (89.26)	26 (10.74)	
	>74	62 (86.11)	10 (13.89)	
Marital status, N (%)	Unmarried	37 (84.09)	7 (15.91)	0.287
	Married	322 (89.44)	38 (10.56)	
Education, n (%)	Elementary school or below	189 (85.52)	32 (14.48)	0.118
	Junior high school	85 (93.41)	6 (6.59)	
	Junior college or high school	45 (91.84)	4 (8.16)	
	College/bachelor or above	38 (95)	2 (5)	
Smoker	No	295 (93.65)	83 (93.26)	0.894
	Yes	20 (6.35)	6 (6.74)	
Alcohol consumption	No	299 (94.92)	86 (96.63)	0.501
	Yes	16 (5.08)	3 (3.37)	
Income, CNY, n (%)	<2000*	163 (82.32)	35 (17.68)	<0.001
	2000–4000	98 (92.45)	8 (7.55)	
	>4000	93 (98.94)	1 (1.06)	
Medical insurance, n (%)	No	331 (88.98)	41 (11.02)	0.799
	Yes	28 (87.5)	4 (12.5)	
Duration of illness, years, n (%)	<5	151 (86.78)	23 (13.22)	0.134
	6–15	154 (88.51)	20 (11.49)	
	>15	54 (96.43)	2 (3.57)	
Expected duration of recovery, months, n (%)	<1	311 (88.86)	39 (11.14)	0.995
	≥1	48 (88.89)	6 (11.11)	
TKA, n (%)	No	323 (88.49)	42 (11.51)	0.472
	Yes	36 (92.31)	3 (7.69)	
OJD, n (%)	No	323 (88.493)	42 (11.51)	0.472
	Yes	36 (92.31)	3 (7.69)	
Trauma, n (%)	No	290 (88.96)	36 (11.04)	0.901
	Yes	69 (88.46)	9 (11.54)	
Hospital stay, days, n (%)	<5	25 (92.59)	2 (7.41)	0.844
	6–8	105 (88.98)	13 (11.02)	
	9–11	107 (89.92)	12 (10.08)	
	>11	120 (86.96)	18 (13.04)	
Daily exercise, minutes, n (%)	None	118 (83.69)	23 (16.31)	0.040
	<30	99 (93.40)	7 (6.60)	
	≥30	142 (90.45)	15 (9.55)	
Body mass index, n (%)	<18.5	3 (60)	2 (40)	0.159
	18.5–24	100 (90.91)	10 (9.09)	
	24–28	143 (87.20)	21 (12.81)	
	>28	113 (90.4)	12 (9.6)	
KOOS-PS_I		60.150 ±4.09	56.156 ±7.94	0.002
KOOS-PS_S		7.685 ±2.06	5.674 ±1.92	<0.001
VAS_C	Decreasing group	297 (94.29)	18 (5.71)	<0.001
	Stable group	62 (69.66)	27 (30.34)	

Notes: Data are shown as mean±SD or n (%). KOOS-PS_I is the intercept term for KOOS-PS, and KOOS-PS_S is the slope term for KOOS-PS. VAS_C is the categorical latent variable of VAS for the decreasing group (n=315) and Stable group (n=89). *100 CNY equals approximately 14.9 USD (April 2019 exchange rate).
Abbreviations: EQ-5D-5L, European Quality of Life Five Dimension Five Level; KOOS-PS, Knee Injury and Osteoarthritis Outcome Score; OJD, Other Joint Diseases.

Table 5 Logistic Regression with EQ-5D-5L_C as the Dependent Variable

Variable	Univariable OR (95% CI)	p-value	Multivariable* OR (95% CI)	p-value
KOOS-PS_I, per SD	2.01 (1.506–2.754)	<0.001	2.26 (1.517–3.519)	<0.001
KOOS-PS_S, per SD	3.26 (2.201–5.014)	<0.001	2.60 (1.656–4.311)	<0.001
Income, CNY				
<2000	Reference		Reference	
2000–4000	2.63 (1.228–6.308)	0.019	6.19 (2.155–21.567)	0.002
>4000	19.97 (4.206–357.716)	0.003	19.73 (3.767–366.688)	0.005
Daily exercise, minutes				
None	Reference		Reference	
<30	2.76 (1.189–7.194)	0.025	2.95 (1.061–9.022)	0.045
≥30	1.85 (0.929–3.764)	0.084	1.62 (0.664–4.024)	0.292
VAS_C				
Stable group	Reference		Reference	
Decreasing group	7.19 (3.758–14.055)	<0.001	6.09 (2.715–14.074)	<0.001

Notes: EQ-5D-5L_C: the categorical latent variable of EQ-5D-5L for the rising group (n=359) and stable group (n=45). The stable group is the reference group. *Adjusted for KOOS-PS_ I, KOOS-PS _S, family monthly income, exercise, VAS_C.
Abbreviations: CI, confidence interval; EQ-5D-5L, European Quality of Life Five Dimension Five Level; KOOS-PS, Knee Injury and Osteoarthritis Outcome Score; OR, odds ratio; VAS, visual analogue scale.

In this study, patients with a monthly family income < 2000 CNY had less improvement in postoperative knee function and HRQoL than their more affluent counterparts, and this difference was observed over a long period of time. Most patients were over the age of 50 years, and those with a monthly family income < 2000 CNY were mostly agricultural or migrant workers. These individuals generally have less health knowledge, a lower socioeconomic status, and relatively poor self-Management skills.[42] For financial reasons, they are less likely to protect their knees when performing daily activities and are more likely to opt for less expensive drugs, medical consumables, and therapies. Furthermore, they often return to work prematurely without adequate rest and rehabilitation after surgery.

Patients in this study who exercised for < 30 min daily had better outcomes than those who did not exercise. An appropriate amount of regular exercise both protects and improves knee function in patients with KOA and accelerates postoperative recovery. Pain was also identified to affect the outcome of TKA, which is consistent with previous reports.[43,44] Pain severely affects both mobility and mental well-being of patients with KOA. Therefore, adequate perioperative pain management is important for these patients. A study found that some patients with KOA and mild pain did not ask for pain relief soon enough and missed the opportunity for intervention in the early stage of inflammation,[42] which led to worsening of the disease. Pain should be controlled effectively in the early stages of KOA, with consideration of interventions such as physical therapy to avoid progression of acute pain to uncontrollable chronic pain. As soon as KOA is diagnosed, doctors and patients' families should make decisions together and cooperate to standardize pain management[45] and encourage patients to exercise as appropriate to help preserve their joint function.

This study had some potential limitations. First, data for 67 patients could not be collected at all five time points; these missing results may have resulted in a reporting bias. Longer term (1–2 years) follow-up should be performed in the future. Second, the size of the stable group in the 2-class GMM was small, meaning that the effects of certain patient factors, such as age, sex, and BMI, might not be well reflected. Future analysis should consider the impact of patient expectation and satisfaction subscores on HRQoL.[46] Third, the effects of TKA were not analyzed according to the implantation method used. Therefore, future studies should investigate the impact of the implantation method and rehabilitation protocol used on postoperative HRQoL in patients who undergo TKA.

Conclusion

Our results demonstrated that TKA can significantly improve HRQoL and knee function in patients with KOA. TKA should be recommended for patients with end-stage KOA and for those who do not respond to pharmacological therapy.

For orthopedic clinicians, patients with poor preoperative joint functional status and who do not perform any exercise are a key concern. Doctors should encourage them to undergo joint rehabilitation training as early as possible, pay attention to joint function exercises, and communicate with doctors about the status of joint function rehabilitation in a timely manner. Health care professionals should also pay more attention to patients' out-of-hospital rehabilitation status and strengthen their health guidance after discharge, including joint function rehabilitation guidance and dietary guidance, so that patients can maximize their HRQoL.

Data Sharing Statement
Data are available from the corresponding author upon reasonable request and are strictly for research purposes.

Ethics Approval
The study was approved by the Ethics Committee of the Third Affiliated Hospital of Southern Medical University (approval number 2018-IORG-10-1) and performed in accordance with the Declaration of Helsinki.

Consent
Written informed consent was obtained from all study participants.

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Author Contributions
All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. DW and CD contributed equally to this work and should be considered co-corresponding authors.

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Disclosure
The authors declare that they have no competing interests in this work.

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