

# A New Prediction Model of Patient Satisfaction After Total Knee Arthroplasty and The Roles of Different Score Systems: A retrospective cohort study

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## Research Article

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# Abstract

## BACKGROUND

Although total knee arthroplasty (TKA) is efficacious treatment for end-stage osteoarthritis, ~20% patients are dissatisfied with the results. We determined which factors contribute to patient satisfaction and compared the various scoring systems before and after surgery.

## METHODS

In this retrospective cohort study, 545 patients were enrolled and were evaluated preoperatively and 1 year postoperatively. Patient demographics, as well as scores for Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Short Form (SF)-12, and 1989 Knee Society Clinical Rating System (KSS) were recorded preoperatively and postoperatively. The possible predictors were introduced into a prediction model. Scores for overall satisfaction and 2011 Knee Society Score (KSS) were also assessed after total knee arthroplasty to identify the accuracy and agreement of the systems.

## RESULTS

There were 134 male patients and 411 female patients, with an overall prevalence of satisfaction of 83.7% 1 year after surgery. A history of surgery ( $p < 0.001$ ), 1989 KSS and SF-12 were of the utmost importance in the prediction model, whereas the WOMAC score had a vital role postoperatively (change of WOMAC pain score,  $p < 0.001$ ; change of WOMAC physical function score,  $p < 0.001$ ; postoperative WOMAC pain score,  $p = 0.004$ ). The agreement between assessment of overall satisfaction and 2011 KSS satisfaction assessment was general ( $\text{Kappa} = 0.437 > 0.4$ ,  $p < 0.001$ ).

## CONCLUSION

A history of surgery, preoperative 1989 KSS and preoperative SF-12 influenced patient satisfaction after primary total knee arthroplasty. We recommend WOMAC (particularly the subscale score of pain) to reflect the overall patient satisfaction postoperatively.

## 1. Introduction

Total knee arthroplasty (TKA) is an efficacious treatment to improve the function and quality of life of patients with end-stage osteoarthritis of the knee<sup>(1,2,3)</sup>. Despite its wide use and popularity, several studies have reported that ~20% of patients are dissatisfied with the outcomes of primary TKA<sup>(3,4)</sup>. Preoperative expectation, the type of prosthesis, sex, age, and psychological factors have been suggested to be related to this low prevalence of patient satisfaction<sup>(3,4,5,6,7,8)</sup>. However, a “gold standard” questionnaire or tool for assessment of patient satisfaction is lacking, means that there are variable results of preoperative predictors.<sup>(2,7)</sup>

In recent decades, patient satisfaction and patient-reported outcome measures have been valued increasingly to assess the overall outcome of surgical procedures from the viewpoint of patients rather than that of surgeons<sup>(2, 5, 7)</sup>. In a recent review, Kahlenberg et al. demonstrated that the most commonly used method of measuring satisfaction is a single question about overall satisfaction that can be answered on an ordinal scale (e.g., “very satisfied”, “somewhat satisfied”, “dissatisfied”, “very dissatisfied”), whereas other scholars have used different Likert scales or multiple questions to assess satisfaction<sup>(9)</sup>. The different methods of satisfaction-reporting and scoring systems lead to difficulty in identifying which patients is truly dissatisfied with the outcomes of primary TKA<sup>(3, 8, 9)</sup>. Moreover, few scholars have compared the method of measuring patient satisfaction or assessed the correlation between the focus of restoration and a postoperative scoring system.

We aimed to assess the prevalence of patient satisfaction after TKA, identify the independent predictors of patient satisfaction preoperatively, and establish a prediction model which could aid management before and after surgery. Also, we aimed to assess the roles of different scales postoperatively, including the connection between the focus of questions and various scoring systems. In addition, we wanted to ascertain the accuracy and agreement between patient satisfaction using the 2011 Knee Society Clinical Rating System (KSS) and overall patient satisfaction.

## **2. Materials And Methods**

### **2.1. Ethical approval for the study protocol**

The study protocol was approved by the Ethics Committee of Hospital (Zhongshan Hospital, Fudan University) (B2020-234R). All patients provided written informed consent for use of their data in the present study.

### **2.2. Inclusion and exclusion criteria**

Only patients with primary osteoarthritis were eligible for study inclusion. Patients who underwent a second TKA or revision arthroplasties, lacked the ability to complete questionnaires, or who had a periprosthetic joint infection during the study period were excluded.

### **2.3. Study design**

This was a retrospective cohort study with a prospectively compiled arthroplasty database in a single institution. Between May 2016 and August 2019, 722 patients undergoing TKA were recruited to our study. Demographic and clinical data were collected based on medical records in the hospital database before surgery.

Scores of various scales were recorded preoperatively using established questionnaires: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)<sup>(10)</sup>, Short Form (SF)-12<sup>(11)</sup>, and 1989 Knee Society Clinical Rating System (KSS)<sup>(12)</sup>.

One year after TKA, each patient was asked to complete another questionnaire consisting of the WOMAC, 1989 KSS, SF-12, overall satisfaction, and 2011 Knee Society Clinical Rating System<sup>(13)</sup>. Finally, 545 of the 722 patients who underwent primary TKA and for whom we had complete form data were included in the study according to the inclusion criteria (Fig 1).

Data were collected by participating surgeons and their staff in hospital. Preoperatively, in addition to various scoring systems, the following data were collected: age; sex; unilateral or bilateral TKA; primary diagnosis; comorbidities; body mass index (BMI); living status (live alone: yes/no); Kellgren–Lawrence grade of osteoarthritis<sup>(14)</sup> and previous surgery. The type of prosthesis was recorded and there was no patella resurfacing during TKA.

One year after TKA, we measured patient satisfaction by asking an overall satisfaction-assessment question<sup>(9)</sup> and four satisfaction-assessment questions of different major aspects (surgical procedure, functional restoration, pain relief, fulfillment of expectation). The questions were (1) “Overall, how satisfied are you with the results of your knee-replacement surgery?”; (2) “How satisfied are you with the surgical procedure for your knee-replacement surgery?”; (3) “How satisfied are you with the results of your knee-replacement surgery for improving your functional abilities (such as standing, walking, and bathing)?”; (4) “How satisfied are you with the results of your knee-replacement surgery for relieving your pain?” (5) “How satisfied are you with the expectation fulfillment of your knee-replacement surgery?”.

The response to each question was recorded using a five-point Likert scale: “very satisfied”, “satisfied”, “neutral”, “dissatisfied”, and “very dissatisfied”. Patients were divided into two groups according to their answer to the question on overall satisfaction. Patients who answered “very dissatisfied”, “dissatisfied”, or “neutral” were assigned to one group. Patients who answered “satisfied” or “very satisfied” were placed in a second group. This two-category outcome (“satisfied”, “not satisfied”/“neutral”) was used as the measure of overall satisfaction for all statistical analyses because patient satisfaction or patient dissatisfaction were our primary variables. Besides, the outcomes of the postoperative score and change in score of WOMAC, 1989 KSS, 2011 KSS, and SF-12 were also collected and calculated.

The classical 1989 KSS we used included measurement of knee and functional outcomes by the surgeon. The 1989 KSS scoring system for measuring clinical outcomes has been validated<sup>(12)</sup>. We also used the new 2011 Knee Society Score (KSS)<sup>(13, 15)</sup> to assess the outcomes of surgery post-operatively, which has four categories: symptoms, patient satisfaction, patient expectations, and functional activities. During recent years, most researchers have preferred to use 2011 KSS because it takes patients’ feelings into account and TKA outcome is measured from different dimensions<sup>(15, 16, 17, 18)</sup>.

WOMAC<sup>(10)</sup> consists of three subscales: pain, physical function, and stiffness. WOMAC comprises 24 questions on a five-point Likert scale (“none”, “mild”, “moderate”, “severe”, and “extreme”). According to recent recommendations, we used the reverse option, from 0 (“worst”) to 100 (“best”)<sup>(19, 20, 21, 22)</sup>.

SF-12 is used frequently to measure well-being. It comprises a physical component summary (PCS) and mental component summary (MCS). The PCS and MCS range from 0 (“worst level of functioning”) to 100 (“best level of functioning”) according to recommendations<sup>(11)</sup>.

## 2.4 Statistical analysis

Statistical analyses were undertaken using 23.0 (IBM, Armonk, NY, USA) and R 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). Different variables were compared between the “satisfied” and “dissatisfied” TKA groups. Categorical variables were tested using the chi-square test. Continuous variables were tested using the independent Student’s t-test or Mann–Whitney U-test between two groups. Correlation analyses were employed to identify the efficiency of the change in score and postoperative score for reflecting patient satisfaction. Univariate and multivariate logistic regression were used to identify independent predictors of satisfaction after surgery. Nomograms and calibration plots were created with the “rms” package to set a predictive model. To identify the possible predictors of four aspects of satisfaction (operative procedure, functional restoration, pain relief, fulfillment of expectation) preoperatively, we analyzed them with preoperative scores and change in scores of the relevant subscales (surgical outcomes of 1989 KSS, 2011 KSS, WOMAC and SF-12; functional-restoration outcome using the function score from 1989 KSS; function score from WOMAC; pain-relief outcome using the pain score from WOMAC; expectation-fulfillment outcome using the expectation score from 2011 KSS). 2011 KSS contains assessment of patient satisfaction as well, so we compared it with overall patient satisfaction by the McNemar and Kappa test.  $P < 0.05$  was considered significant.

## 3. Results

### 3.1. Patient satisfaction and prediction model

The patient demographics, comorbidities, relevant clinical data and scores of different scales for the study cohort are illustrated in Table 1 and Table 2, respectively. There were 134 male patients and 411 female patients, with a mean age of 72.2 years and a mean body mass index (BMI) of 26.1. There was a significant improvement in all scoring systems post-operatively. The average 1-year 1989 KSS knee score was  $83.42 \pm 12.81$  with a change score of  $36.90 \pm 13.47$ . The average 1-year 1989 KSS functional score was  $76.62 \pm 19.98$  with a change score of  $40.24 \pm 15.48$ . The mean 1-year WOMAC pain score was  $83.10 \pm 17.13$  with a change score of  $55.51 \pm 17.63$ . The mean 1-year WOMAC joint stiffness score was  $84.53 \pm 15.62$  with a change score of  $27.44 \pm 19.59$ . The mean 1-year WOMAC function score was  $62.36 \pm 11.33$  with an average improvement of  $26.56 \pm 13.19$ . The average 1-year SF-12 PCS score was  $48.04 \pm 7.05$  with an average change of  $13.62 \pm 7.67$ . The average 1-year SF-12 MCS score was  $43.08 \pm 6.73$  with an average change of  $11.12 \pm 8.58$ .

**Table 1. Univariate statistical analysis results of demographic and clinical variables between satisfaction outcome groups (satisfied/very satisfied, dissatisfied/very dissatisfied/neutral)**

Variables	Satisfied [n=456]	Dissatisfied [n=89]	Significance (p)
Age (mean±SD)	72.02±6.60	73.05±6.70	0.147
BMI(mean±SD)	26.01±3.47	26.21±3.58	0.629
Female	337(73.9%)	74(83.1%)	0.064
Unilateral(n,%)	425(93.2%)	86(96.6%)	0.221
Comorbidity(n,%)	340(74.6%)	61(68.5%)	0.239
Live alone(n,%)	33(7.2%)	8(9.0%)	0.567
K-L grades(mean±SD)	3.76±0.42	3.78±0.43	0.704
Implant type(n,%)			0.218
GII	134(29.4%)	32(36.0%)	
LEGION	322(70.6%)	57(64.0%)	
Previous surgery history(n,%)	256(56.1%)	69(77.5%)	<0.001*
Orthopaedic surgery history(n,%)	129(28.2%)	30(33.7%)	0.183
Frequency<2(n,%)	317(69.5%)	66(74.2%)	0.228
Frequency<2(n,%)	405(88.8%)	82(92.1%)	0.234

\*Statistically significant

**Table 2. Univariate statistical analysis results of various scoring systems between satisfaction outcome groups (satisfied/very satisfied, dissatisfied/very dissatisfied/neutral)**

Variables	Satisfied [n=456]	Dissatisfied [n=89]	Significance (p)	Correlation coefficient between variables and overall satisfaction (r)
<b>Preoperative 1989 KSS</b>				
Knee(mean±SD)	48.66±10.85	35.61±12.03	<0.001*	-0.372
Function(mean±SD)	39.21±9.02	21.91±18.66	<0.001*	-0.370
Total(mean±SD)	87.87±15.19	57.52±27.54	<0.001*	-0.432
<b>Postoperative 1989 KSS</b>				
Knee(mean±SD)	85.66±9.87	71.97±18.74	<0.001*	-0.292
Function(mean±SD)	82.11±13.00	48.54±25.30	<0.001*	-0.493
Total(mean±SD)	167.77±16.84	120.51±38.61	<0.001*	-0.504
<b>Change 1989 KSS</b>				
Knee(mean±SD)	37.00±12.84	36.36±16.39	<0.001*	-0.011
Function(mean±SD)	42.89±14.39	26.63±13.65	<0.001*	-0.390
Total(mean±SD)	79.89±19.46	62.99±22.31	<0.001*	-0.283
<b>Preoperative WOMAC</b>				
Pain(mean±SD)	27.99±10.98	25.56±13.21	0.031*	-0.084
Joint(mean±SD)	58.83±23.92	48.17±23.88	<0.001*	-0.166
Function(mean±SD)	36.22±9.07	33.65±9.82	0.016*	-0.106
Total(mean±SD)	41.01±9.96	35.80±10.22	<0.001*	-0.183
<b>Postoperative WOMAC</b>				
Pain(mean±SD)	87.73±10.75	59.38±23.15	<0.001*	-0.470
Joint(mean±SD)	86.27±14.81	75.62±16.69	<0.001*	-0.248
Function(mean±SD)	64.65±9.63	50.63±12.17	0.790	-0.405
Total(mean±SD)	79.55±7.76	61.87±11.36	<0.001*	-0.523

<b>Change WOMAC</b>				
Pain(mean±SD)	59.75±12.74	33.81±22.64	<0.001*	-0.427
Joint(mean±SD)	27.44±20.11	27.44±16.79	0.019*	0.005
Function(mean±SD)	28.43±12.26	16.97±13.70	<0.001*	-0.290
Total(mean±SD)	38.54±9.12	26.08±11.79	0.002*	-0.378
<b>Preoperative SF-12</b>				
PCS(mean±SD)	35.59±7.27	28.42±5.34	0.002*	-0.371
MCS(mean±SD)	32.52±6.70	29.03±5.67	<0.001*	-0.207
<b>Postoperative SF-12</b>				
PCS(mean±SD)	49.71±5.26	39.46±8.69	<0.001*	-0.454
MCS(mean±SD)	43.95±6.43	38.60±6.45	<0.001*	-0.280
<b>Change SF-12</b>				
PCS(mean±SD)	14.12±7.66	11.04±7.22	<0.001*	-0.155
MCS(mean±SD)	11.43±8.50	9.57±8.85	0.062	-0.070
<b>Postoperative 2011 KSS</b>				
Symptom(mean±SD)	15.52±2.33	12.24±2.64	<0.001*	-0.402
Satisfaction (mean±SD)	29.31±6.93	16.48±7.52	<0.001*	-0.495
Expectation(mean±SD)	12.17±2.23	6.96±2.59	<0.001*	-0.551
Function (mean±SD)	67.80±13.02	37.66±15.51	<0.001*	-0.543

\*Statistically significant

1989 KSS, 1989 Knee Society Clinical Rating System ; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; SF-12, 12-Item Short-Form Health Survey; PCS, Physical Component Score; MCS, Mental Component Score; 2011 KSS, 2011 Knee Society Score.

Overall satisfaction represented the satisfaction outcome overall. 456 patients claimed that they were satisfied or very satisfied, whereas 89 patients were very dissatisfied, dissatisfied, or neutral. There was an obvious difference in postoperative scores and change in scores between the two groups (Table 2). For a different focus of assessment of satisfaction, 83.5% of patients were satisfied with the surgical procedure, 81.7% of patients were satisfied with postoperative functional restoration, 79.6% of patients were satisfied with pain relief and 82.0% of patients were satisfied with their fulfillment of expectation. Most subscale scores of different scoring systems were highly correlated to the outcome of overall satisfaction. With regard to the correlation coefficient, it was more reasonable to assess postoperative overall satisfaction with postoperative scores rather than change in scores (Table 2).

**Table 3 Predictors of overall patient satisfaction after TKA on multivariate analysis**

	B (95% CI)	p value
<b>Preoperative scores</b>		
1989 KSS knee score	0.048[-1.021, 1.077]	<0.001*
1989 KSS function score	0.066[-1.041, 1.097]	<0.001*
WOMAC pain score	0.016[-0.991, 1.042]	0.220
WOMAC joint score	0.008[-0.996, 1.021]	0.206
WOMAC function score	0.012[-0.979, 1.046]	0.488
PCS score	0.071[-1.022, 1.128]	0.004*
MCS score	0.127[-1.077, 1.196]	<0.001*
<b>Change scores</b>		
1989 KSS knee score	-0.004[-0.973, 1.019]	0.708
1989 KSS function score	0.051[-1.030, 1.076]	<0.001*
WOMAC pain score	0.074[-1.056, 1.099]	<0.001*
WOMAC joint score	-0.007[-0.977, 1.010]	0.423
WOMAC function score	0.050[-1.025, 1.079]	<0.001*
PCS score	0.019[-0.979, 1.061]	0.355
<b>Postoperative scores</b>		
1989 KSS knee score	0.021[-0.979, 1.064]	0.330
1989 KSS function score	0.006[-0.978, 1.035]	0.687
WOMAC pain score	0.054[-1.017, 1.094]	0.004*
WOMAC joint score	0.012[-0.982, 1.043]	0.446
PCS score	-0.006[-0.912, 1.083]	0.889
MCS score	-0.036[-0.878, 1.060]	0.454
2011 symptom score	-0.028[-0.755, 1.252]	0.826

<b>2011 satisfaction score</b>	<b>0.154</b> □ <b>1.080</b> □ <b>1.261</b> □	<b>&lt;0.001*</b>
<b>2011 expectation score</b>	<b>0.539</b> □ <b>1.307</b> □ <b>2.247</b> □	<b>&lt;0.001*</b>
<b>2011 function score</b>	<b>0.067</b> □ <b>1.033</b> □ <b>1.107</b> □	<b>&lt;0.001*</b>

\*Statistically significant

1989 KSS, 1989 Knee Society Clinical Rating System ; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; SF-12, 12-Item Short-Form Health Survey; PCS, Physical Component Score; MCS, Mental Component Score; 2011KSS, 2011 Knee Society Score.

For the preoperative predictors of overall satisfaction identified by binary logistic regression analysis, dissatisfaction with the overall outcome was more likely in patients who had undergone surgery previously. Further analyses using the chi-square test revealed no significant difference in the prevalence and type of previous surgical procedure (Table 1). With regard to preoperative scores, patients were more likely to feel dissatisfied if they had lower 1989 KSS or SF-12 score (Table 3). To establish a prediction model to assess the possibility of dissatisfaction, we constructed a nomogram on the basis of 1989 KSS ,SF-12 and previous surgical procedure. The calibration curve of the nomogram demonstrated good agreement between prediction and satisfaction outcomes in both cohorts (Figure 2).

### 3.2. Roles of different scoring systems in satisfaction

For the postoperative scores and improvement in scores of scoring systems, linear regression (Table 2) and multivariate logistic regression (Table 3) revealed that dissatisfaction was more likely in patients with: less change in the pain score ( $p < 0.001$ ) or physical function score ( $p < 0.001$ ) in WOMAC; less change in 1989 KSS knee score ( $p < 0.001$ ); lower postoperative WOMAC pain score ( $p = 0.004$ ); lower postoperative expectation, satisfaction and function score in 2011 KSS ( $p < 0.001$ ). In general, we recommend WOMAC, particularly the subscale score of pain, to reflect overall patient satisfaction 1 year after surgery.

Dissatisfaction with the surgical procedure was more likely in patients with: a lower preoperative 1989 KSS or SF-12 score; less improvement in the function score in 1989 KSS; less improvement of the physical-function or pain score in WOMAC and less improvement of SF-12. Dissatisfaction with functional restoration was more likely in patients with: a lower preoperative functional score in 1989 KSS ( $p < 0.001$ ); less improvement of functional score in 1989 KSS ( $p < 0.001$ ); lower patient-expectation score in 2011 KSS ( $p < 0.001$ ). Dissatisfaction with pain relief was more likely in patients with less improvement of pain score in WOMAC ( $p < 0.001$ ), which is surprisingly unrelated to preoperative pain score. Dissatisfaction with fulfillment of expectation was more likely in patients with a lower expectation score in 2011 KSS ( $p < 0.001$ ) (Table 4).

### Table 4 Predictors of different aspects of patient satisfaction after TKA on multivariate analysis or linear regression analysis

Predictors in different aspects	B (95% CI)	p value
<b>Satisfaction with operation</b>		
Preoperative 1989 KSS knee score	0.035[-1.012, 1.059]	0.003
Preoperative 1989 KSS functionscore	0.036[-1.016, 1.058]	<0.001
Preoperative PCS	0.021[-1.031, 1.120]	0.001
Preoperative MCS	0.021[-1.001, 1.087]	0.046
Change 1989 KSS function score	0.033[-1.015, 1.053]	<0.001
Change WOMAC pain score	0.040[-1.026, 1.056]	<0.001
Change WOMAC function score	0.020[-1.000, 1.041]	0.045
<b>Satisfaction with pain relief</b>		
Change WOMAC pain score	-0.012[-0.013, -0.010]	<0.001
<b>Satisfaction with functional restoration</b>		
Preoperative 1989 KSS function score	-0.009[-0.012, -0.007]	<0.001
Change 1989 KSS function score	-0.006[-0.009, -0.004]	<0.001
<b>Satisfaction of fulfillment of expectation</b>		
2011 KSS expectation score	-0.058[-0.068, -0.048]	<0.001

1989 KSS, 1989 Knee Society Clinical Rating System ; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; 2011 KSS, 2011 Knee Society Score.

### 3.3. Accuracy and agreement of satisfaction measurements

We compared the assessment of patient satisfaction from 2011 KSS (the cut-off point of analysis of the receiver operating characteristic curve was used to define the satisfaction and dissatisfaction outcomes) with the outcome of overall patient satisfaction by the paired chi-square test and McNemar test. The patient satisfaction gained from the two methods was dissimilar ( $p=0.001 < 0.05$ , 83.7% versus 70.1%), but the agreement between the two methods was general ( $Kappa=0.437 > 0.4$ ,  $p < 0.001$ ).

## 4. Discussion

We revealed that the prevalence of overall satisfaction postoperatively was ~80%, which is consistent with data from most reports. We demonstrated that not having undergone surgery before TKA was of utmost importance in achieving patient satisfaction. Compared with other preoperative scoring systems, 1989 KSS and SF-12 had a vital role in predicting satisfaction. For the different scoring systems, although most scores and change in scores could indicate overall patient satisfaction postoperatively, the postoperative outcomes were obviously better tools, and the WOMAC subscale score of pain had an explicit advantage among the scoring systems we tested. The predictors of different aspects of patient satisfaction also varied according to the focus of the question on satisfaction.

Traditionally, the outcomes of TKA have been assessed by surgeons using non-validated scoring systems. However, in recent decades, patient-reported outcomes have become popular for assessing postoperative outcomes<sup>(2, 5)</sup>. Kahlenberg and colleagues showed that most studies use variable methods for measuring and reporting satisfaction, and researchers ought to focus on standardizing reporting of patient satisfaction and defining ways to optimize patient satisfaction after TKA<sup>(9)</sup>. We not only compared the most-used method with the validated method of measuring patient satisfaction, we also provided suggestions to promote satisfaction levels. This approach reinforces the importance of choosing different scoring systems to predict or reflect patient satisfaction at different periods.

Patient satisfaction 1 year after primary TKA was 83.7%, a value that is consistent with that reported recently<sup>(3, 4, 23, 24)</sup>. We found that most scoring systems reflected patient satisfaction reliably. There was a correlation between satisfaction and improvements in pain and physical-function outcomes in different scoring systems. Several reports have ignored the influence of the pain score in WOMAC, but they used too few scoring systems to discover the significant differences<sup>(7, 25)</sup>. Scholars have highlighted the importance of 1989 KSS and SF-12 for predicting and enhancing patient satisfaction<sup>(7, 26)</sup>. However, they neglect the correlation between SF-12 score with overall patient-satisfaction prediction due in part to the focus of satisfaction questions and study designs being varied<sup>(7)</sup>.

Age and BMI have been a controversial topic. Giesinger et al. found a negative impact of BMI on postoperative improvement in satisfaction scores<sup>(27)</sup>. Cottom et al. imposed a cut-off of 55 years for patient satisfaction<sup>(28)</sup>. Several authors have doubted the effect of age or BMI on patient satisfaction<sup>(29, 30)</sup>. Clement et al. stated that age <55 years was not an independent predictor of functional outcome or patient satisfaction<sup>(31)</sup>. Neither age nor BMI was included in our prediction model, which may have been the result of having few patients aged <55 years and ethnic differences in weight.

The predictors of different major aspects of patient satisfaction after primary TKA varied from each other because of a lack of clear definition of dimensions surgeons should pay attention to. Mahomed et al. developed a validated method for evaluating overall satisfaction, as well as satisfaction with pain relief, ability to do housework, and with the ability to undertake recreational activities. However, they did not include the fulfillment of expectation, which has been shown to be vital for patient satisfaction<sup>(32)</sup>.

The primary strength of our study was a general comparison of different scoring systems preoperatively and postoperatively, which highlights the importance of the 1989 KSS and SF-12 score preoperatively and WOMAC score postoperatively. Based on our findings, surgeons can adjust management before and after surgery to achieve a higher prevalence of patient satisfaction after primary TKA. Besides, our study suggests the possibility of predicting patient satisfaction through previous surgical history, but further research is needed to investigate the relationship between them. In addition, for the first time, we contrasted the methods of measuring satisfaction: patient satisfaction from 2011 KSS<sup>(33, 34)</sup> and a single question of overall satisfaction.

Our study had five main limitations. First, the sample size was small and only 75.5% of eligible patients completed all required forms. Second, our data may be unrepresentative of the general population and raise the risk of biases. Third, we assessed patient expectations only by asking whether expectations had been met or not, without the evaluation of expectations preoperatively. Fourth, we only compared different scoring systems to discover the possible predictors of various aspects of patient satisfaction: we did not analyze demographic or clinical data. Fifth, we assessed all patient satisfaction 1 year after TKA. The perception and feeling of pain and function may continue to improve and promote the level of satisfaction, so a longer follow-up would have been a good strategy.

## 5. Conclusions

A history of surgery, preoperative 1989 KSS and preoperative SF-12 influenced patient satisfaction after primary TKA. We recommend WOMAC (particularly the subscale score of pain) to reflect the overall patient satisfaction postoperatively.

## 6. Declarations

### **Ethics approval and consent to participate**

The study protocol was approved by the Ethics Committee of Hospital (Zhongshan Hospital, Fudan University, B2020-234R). All patients provided written informed consent for use of their data in the present study.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The datasets generated and/or analysed during the current study are not publicly available due to the data application regulations of hospital but are available from the corresponding author on reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

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## Authors' contributions

Study concept and design: Jinyu Liu, Yi Yang and Chi Zhang. Data analysis and interpretation: all authors. Manuscript preparation: Jinyu Liu and Shengcheng Wan. All authors read and approved the final manuscript.

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Not applicable.

## References

- 1 Price Andrew J, Alvand Abtin, Troelsen Anders, et al. 2018. Knee replacement. *Lancet [J]*, 392: 1672–1682.
- 2 Van Onsem Stefaan, Van Der Straeten Catherine, Arnout Nele, et al. 2016. A New Prediction Model for Patient Satisfaction After Total Knee Arthroplasty. *The Journal of arthroplasty [J]*, 31: 2660–2667.e2661.
- 3 Bourne Robert B, Chesworth Bert M, Davis Aileen M, et al. 2010. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clinical orthopaedics and related research [J]*, 468: 57–63.
- 4 Noble P C , Conditt M A , Cook K F, et al. 2006. The John Insall Award: Patient expectations affect satisfaction with total knee arthroplasty. *Clinical orthopaedics and related research [J]*, 452: 35–43.
- 5 Baker P N, van der Meulen J H, Lewsey J, et al. 2007. The role of pain and function in determining patient satisfaction after total knee replacement. Data from the National Joint Registry for England and Wales. *The Journal of bone and joint surgery. British volume [J]*, 89: 893–900.
- 6 Vissers MM, Bussmann JB, Verhaar JA, et al. Psychological factors affecting the outcome of total hip and knee arthroplasty: a systematic review. *Semin Arthritis Rheum 2012*; 41: 576–588.
- 7 Clement N D, Bardgett M, Weir D, et al. 2018. The rate and predictors of patient satisfaction after total knee arthroplasty are influenced by the focus of the question: a standard satisfaction question is required. *The bone & joint journal [J]*: 740–748.
- 8 Gunaratne Rajitha, Pratt Dylan N, Banda Joseph, et al. 2017. Patient Dissatisfaction Following Total Knee Arthroplasty: A Systematic Review of the Literature. *The Journal of arthroplasty [J]*, 32: 3854–3860.

- 9 Kahlenberg Cynthia A, Nwachukwu Benedict U, McLawhorn Alexander S, et al. 2018. Patient Satisfaction After Total Knee Replacement: A Systematic Review. *HSS journal : the musculoskeletal journal of Hospital for Special Surgery [J]*, 14: 192–201.
- (10) Bellamy N, Buchanan W, Goldsmith C, et al. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol* 1988; 15: 1833–1840.
- (11) Ware J, Kosinski M, Keller S. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 1996; 34: 220–233.
- (12) Insall J, Dorr L, Scott R, et al. Rationale of the Knee Society clinical rating system. *Clin Orthop Rel Res* 1989; 248: 13–14.
- (13) Noble P, Scuderi G, Brekke A, et al. Development of a new Knee Society scoring system. *Clin Orthop Rel Res* 2012; 470: 20–32.
- (14) Kellgren J, Lawrence J. Radiological assessment of osteo-arthrosis. *Ann Rheum Dis* 1957; 16: 494–502.
- (15) Scuderi G, Bourne R, Noble P, et al. The new Knee Society Knee Scoring System. *Clin Orthop Rel Res* 2012; 470: 3–19.
- (16) Tsukiyama H, Kuriyama S, Kobayashi M, et al. Medial rather than lateral knee instability correlates with inferior patient satisfaction and knee function after total knee arthroplasty. *Knee* 2017; 24: 1478–1484.
- (17) Kamenaga T, Muratsu H, Kanda Y, et al. The influence of postoperative knee stability on patient satisfaction in cruciate-retaining total knee arthroplasty. *J Arthroplasty* 2018; 33: 2475–2479.
- (18) Furu M, Ito H, Nishikawa T, et al. Quadriceps strength affects patient satisfaction after total knee arthroplasty. *J Orthop Sci* 2016; 21: 38–43.
- (19) Xie F, Li S, Goeree R, et al. Validation of Chinese Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) in patients scheduled for total knee replacement. *Qual Life Res* 2008; 17: 595–601.
- (20) Bellamy N. WOMAC: a 20-year experiential review of a patient-centered self-reported health status questionnaire. *J Rheumatol* 2002; 29: 2473–2476.
- (21) Walker L, Clement N, Bardgett M, et al. The WOMAC score can be reliably used to classify patient satisfaction after total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc* 2018; 26: 3333–3341.

- (22) Singh J, Sloan J, Johanson N Challenges with health-related quality of life assessment in arthroplasty patients: problems and solutions. *J Am Acad Orthop Surg* 2010; 18: 72–82.
- (23) Farooq H, Deckard E, Ziemba-Davis M, et al. Predictors of patient satisfaction following primary total knee arthroplasty: results from a traditional statistical model and a machine learning algorithm. *J Arthroplasty* 2020; S0883-5403: 30618-5.
- (24) Khatib Y, Badge H, Xuan W, et al. Patient satisfaction and perception of success after total knee arthroplasty are more strongly associated with patient factors and complications than surgical or anaesthetic factors. *Knee Surg Sports Traumatol Arthrosc* 2020; doi: 10.1007/s00167-019-05804-9. Online ahead of print.
- (25) Thambiah M, Nathan S, Seow B, et al. Patient satisfaction after total knee arthroplasty: an Asian perspective. *Singapore Med J* 2015; 56: 259–263.
- (26) Lützner C, Postler A, Beyer F, et al. Fulfillment of expectations influence patient satisfaction 5 years after total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc* 2019; 27: 2061–2070.
- (27) Giesinger J, Loth F, Macdonald D, et al. Patient-reported outcome metrics following total knee arthroplasty are influenced differently by patients' body mass index. *Knee Surg Sports Traumatol Arthrosc* 2018; 26: 3257–3264.
- (28) Cottom J, Graney C, Douthett S, et al. Age-related outcomes in total ankle arthroplasty: an analysis of 112 patients. *J Foot Ankle Surg* 2020; 59: 739–742.
- (29) Overgaard A, Lidgren L, Sundberg M, et al. Patient-reported 1-year outcome not affected by body mass index in 3,327 total knee arthroplasty patients. *Acta Orthop* 2019; 90: 360–365.
- (30) Jacobs C, Christensen C. Factors influencing patient satisfaction two to five years after primary total knee arthroplasty. *J Arthroplasty* 2014; 29: 1189–1191.
- (31) Clement N, Walker L, Bardgett M, et al. Patient age of less than 55 years is not an independent predictor of functional improvement or satisfaction after total knee arthroplasty. *Arch Orthop Trauma Surg* 2018; 138: 1755–1763.
- (32) Clement N, Bardgett M, Weir D, et al. Increased symptoms of stiffness 1 year after total knee arthroplasty are associated with a worse functional outcome and lower rate of patient satisfaction. *Knee Surg Sports Traumatol Arthrosc* 2019; 27: 1196–1203.
- (33) Dinjens R, Senden R, Heyligers I, et al. Clinimetric quality of the new 2011 Knee Society score: high validity, low completion rate. *Knee* 2014; 21: 647–654.
- (34) Kuroda Y, Matsumoto T, Takayama K, et al. Subjective evaluation before and after total knee arthroplasty using the 2011 Knee Society Score. *Knee* 2016; 23: 964–967.

# Figures

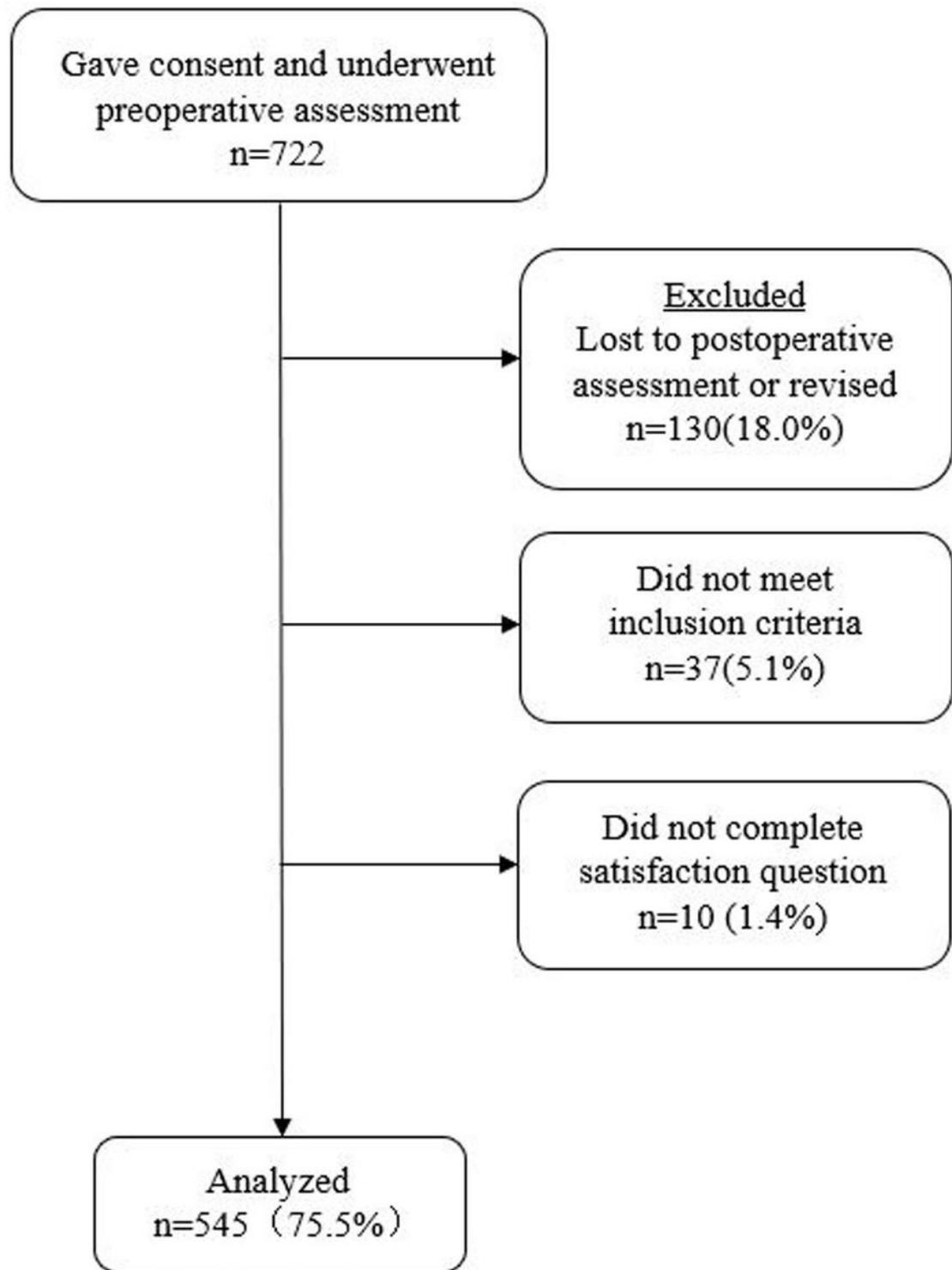
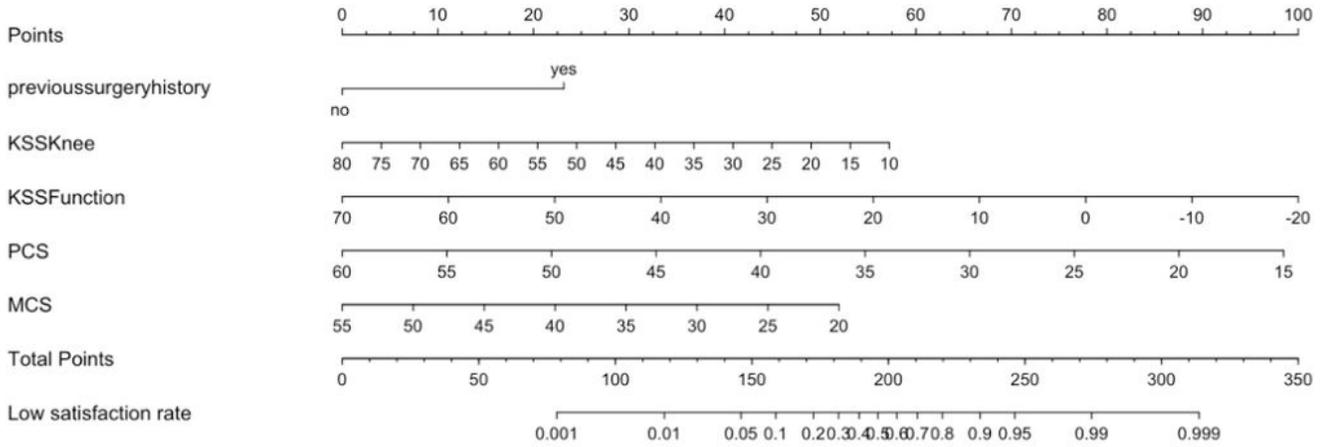
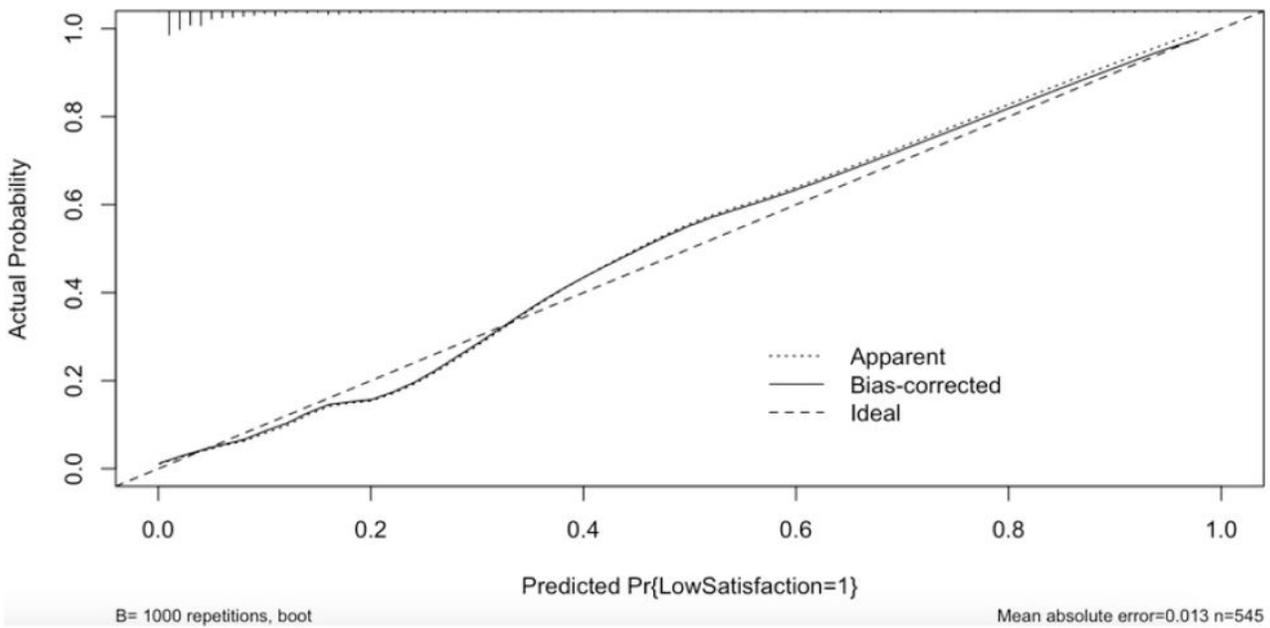


Figure 1

Flowchart illustrating the study cohort



(A)



(B)

**Figure 2**

Construction of nomogram. Nomogram for predicting patient satisfaction for the included patients(A). Calibration curves of nomograms in terms of agreement between prediction and satisfaction outcomes(B).