Development and Validation of a New Evaluation System for Patients With a Floor-based Lifestyle: The Korean Knee Score

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Abstract

Background Patients' perspectives on functioning and health have been increasingly recognized as a crucial aspect of health care, leading to the use of patient-reported instruments for outcome assessment. However, available instruments for total knee arthroplasty do not reflect the floor-based lifestyle with high knee flexion of eastern Asia. **Questions/purposes** We therefore (1) describe a novel patient-generated knee evaluation instrument, the Korean knee score (KKS), to reflect floor-based lifestyles with high knee flexion that included questions regarding health-related

quality of life; (2) determined the reliability of the questionnaire; and (3) performed limited validation studies.

Methods The KKS was developed by a committee of 10 experts from 10 institutes nationwide. The development procedure comprised a development phase for generation of the questionnaire and a testing phase for assessment of measurement properties: reliability, validity, and responsiveness. A total of 634 patients participated in this test survey.

Results The KKS exhibited an intraclass correlation coefficient of 0.931 and internal consistency (Cronbach's $\alpha = 0.973$). The absence of a ceiling or floor effect suggested content validity. The correlation coefficient with Knee Society score (knee score, function score) and Oxford knee score was 0.599, 0.690, and 0.871, respectively, suggesting construct validity. Correlation with concurrent measures of physical function from the SF-36 ranged from 0.549 to 0.719 and those of mental function from 0.407 to 0.428. Responsiveness was evident with a standardized response mean of 0.74.

Conclusions The KKS is a reliable and responsive instrument for assessing osteoarthritis. The limited validation studies suggest it is an appropriate evaluation instrument for patients with osteoarthritis and a floor-based lifestyle.

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Introduction

The assessment of disease severity and the efficacy of different treatment methods are essential for determining appropriate treatments for patients. From clinical examination to imaging studies, numerous methods of evaluation have been introduced and used. Although objective measures of outcomes such as ROM, static instability grade, and muscle strength are commonly used, they reportedly

only weakly correlate with patient function, general status, and health-related quality of life (HRQOL) [9, 10, 18].

Patients' perspectives on functioning and health have been increasingly recognized in recent years, leading to the use of patient-reported instruments to assess outcomes [7, 16, 20]. A large variety of patient-derived scoring systems for individuals with knee problems has been developed worldwide [1]. Some systems such as the International Knee Documentation Committee (IKDC) subjective knee score [8], the WOMAC osteoarthritis index [2], and the Knee Injury and Osteoarthritis Outcome Score (KOOS) [17] were developed and validated using statistical methods derived from the field of psychophysics, including measures of validity, reliability, and responsiveness. However, the commonly used instruments noted were developed by Western researchers and do not reflect the floor-based lifestyle with high knee flexion of daily life in Asia or of some religious activities such as Muslim or Buddhist prayer. Moreover, many constituent questions are unsuitable for elderly patients in rural areas.

Therefore, in 2009 the Korean Knee Society undertook the development of a novel knee evaluation system that could be applied to osteoarthritis of the knee, especially for patients demanding high knee flexion. The instrument was designed as a patient-derived assessment system and includes questions regarding HRQOL. Importantly, this new instrument aims to reflect a floor-based lifestyle with high knee flexion.

The purposes of this our study were therefore to (1) describe a novel patient-generated knee evaluation instrument, the Korean knee score (KKS), to reflect floor-based lifestyles with high knee flexion that included questions regarding health-related quality of life; (2) determine the reliability of the questionnaire; and (3) perform limited validation studies.

Materials and Methods

In 2009, the Korean Knee Society launched a special research committee for the development of a novel knee evaluation system, the KKS, for patients with osteoarthritis and a floor-based lifestyle. The committee was composed of 10 orthopaedic specialists, who represented the active clinical centers for osteoarthritis, and two statisticians. The development and validation of the new scale followed the guidelines of the International Society of Arthroscopy, Knee Surgery & Orthopaedic Sports Medicine [9], which present two phases and nine steps for the development and testing of disease-specific quality-of-life measurement (Fig. 1).

The characteristics of the population for whom the instrument is designed should first be defined and the

Fig. 1 Flowchart of the developmental procedures of the KKS is shown.

instrument's primary purpose decided. The committee decided to design the new instrument for individuals with osteoarthritis aged > 60 years and to produce an evaluative (detecting important changes in health status over time) and discriminative (differentiating among patients with different levels of health at one time point) instrument.

The new instrument was composed of four subdomains: pain and symptoms, physical function, evaluation of floor-based lifestyle, and socioemotional function. Three steps were followed for item generation. First, the committee members reviewed the literature and selected items from

previous instruments (WOMAC, KOOS, and SF-36) [2, 14, 15, 17]. Second, the 10 experts on the committee provided their opinions and seven novel items were generated. The most important step is interviewing patients with osteoarthritis. Five such patients were interviewed and asked to identify how their condition interfered with their quality of life. This step did not result in the generation of new items.

These initial steps generated 41 items in four subdomains (Table 1). Twelve items were in the pain and symptoms subdomain: seven (nocturnal pain, pain on sitting or lying, pain on standing, pain on using stairs, pain during walking, morning stiffness, stiffness in the afternoon) were selected from the WOMAC instrument and six (pain on straightening fully, pain on bending fully, swelling, grinding or clicking sensation, catching, or hang up) were from the KOOS instrument. The physical function subdomain contained 17 items, all of which were from the WOMAC instrument: descending stairs, ascending stairs, rising from sitting, standing, bending, walking, getting in/out of a car, shopping, putting on socks, taking off socks, rising from bed, lying in bed, getting in/out of a bath, sitting, getting on/off the toilet, heavy household duties, and light household duties. The evaluation of the floor-based lifestyle subdomain included six items, all of which were newly generated by the committee: kneeling pain, pain on squatting, pain on standing up from the floor, pain on sitting with crossed legs on the floor, difficulty on sitting with crossed legs, and difficulty on rising from a sofa or low chair. The socioemotional function subdomain contained six items: awareness, lifestyle modification, lack of confidence, general difficulties, and social functioning as well as a new traveling item added by the committee.

To reduce the number of items, the authors surveyed 50 patients and asked two questions for each item: “Have you ever experienced this problem?” and “How important is this item to you?” The frequency was determined as the proportion of patients experiencing a particular item and the importance score was rated by the patients using a 5-point Likert scale (1–5). Impact scores were calculated by multiplying the frequency by the mean importance score of each item. Thirty-five (items of the socioemotional subdomain were excluded) items were administered to the patients and they were listed in order of the score (Table 2). Mean value of impact score of each subdomain was 1.95 for pain and symptom, 2.34 for physical function, and 3.22 for evaluation of floor life, which was highest of the three subdomains. Five of six items of evaluation of floor life showed higher ranks (within top 10). Although some items from the WOMAC showed low impact scores, the committee (including the two statisticians) decided not to discard any items at this stage, because we intended to develop a new questionnaire including all items of the WOMAC.

Table 1. Items of the Korean knee score

Subdomain	Items
Pain and symptoms	Nocturnal pain
	Pain on sitting or lying
	Pain on standing
	Pain on using stairs
	Pain during walking
	Pain on straightening fully
	Pain on bending fully
	Morning stiffness
	Stiffness at afternoon
	Swelling
Physical functions	Feeling grinding or clicking
	Catching or hang up
	Descending stairs
	Ascending stairs
	Rising from sitting
	Standing
	Bending
	Walking
	Getting in/out of a car
	Shopping
	Putting on socks
	Taking off socks
	Rising from bed
	Lying in bed
	Getting in/out of bath
	Sitting
	Getting on/off toilet
Evaluation of floor-based lifestyle	Heavy household duties
	Light household duties
	Kneeling pain
	Pain on squatting
	Pain on standing up from the floor
	Pain on sitting with crossed leg on the floor
Socioemotional function	Difficulty on sitting with crossed legs
	Difficulty on rising from sofa or low chair
	Awareness
	Lifestyle modification
	Lack of confidence
	General difficulties
	Social functioning
	Traveling

We sought to avoid ambiguity, double-barreled questions (in which two or more questions are asked simultaneously), and jargon in the instrument. The questions were reformed with positive wording and responses were formatted by a 5-category Likert scale. All items were given equal weight.

Fifteen subjects with educational levels up to 12 years old (roughly a grade six level of reading), who had not been involved in the previous development stages, were recruited and asked to read each item aloud and give their interpretation to an interviewer to evaluate the clarity of wording and the interpretation of each item [4, 9]. The authors revised the questionnaire according to subjects' responses.

Table 2. Impact score of items

Rank	Subdomains	Impact score	Items
1	2	4.18	Difficulty on heavy household duties
2	3	4.16	Pain on sitting with crossed leg on the floor
3	3	3.33	Kneeling pain
4	3	3.28	Pain on squatting
5	2	3.2	Difficulty on getting in/out of a car
6	1	3.19	Pain on using stairs
7	3	3.19	Pain on standing up from the floor
8	2	3.11	Difficulty on descending stairs
9	2	3.11	Difficulty on ascending stairs
10	3	3.06	Difficulty on rising from sofa or low chair
11	1	2.92	Pain on bending fully
12	2	2.79	Difficulty on light household duties
13	1	2.61	Pain during walking
14	2	2.57	Difficulty on rising from sitting
15	2	2.53	Difficulty on shopping
16	1	2.53	Swelling
17	2	2.41	Difficulty on bending
18	3	2.31	Pain on sitting with crossed leg on the floor
19	1	2.31	Morning stiffness
20	2	2.17	Difficulties on standing
21	2	2.06	Difficulties on walking
22	2	2.03	Difficulties on getting on/off toilet
23	2	2	Difficulties getting in/out of bath
24	1	1.97	Stiffness at afternoon
25	1	1.88	Feeling grinding an clicking
26	2	1.77	Difficulties on rising from bed
27	1	1.67	Pain on standing
28	2	1.66	Difficulties on lying in bed
29	1	1.58	Pain on straightening fully
30	2	1.47	Difficulties putting on socks
31	2	1.36	Difficulties on sitting
32	2	1.34	Difficulties taking off socks
33	1	0.97	Nocturnal pain
34	1	0.94	Pain on sitting
35	1	0.86	Catching or hang up

Subdomain 1 = pain and symptoms; 2 = physical function; 3 = evaluation of floor-based lifestyle; 4 = socioemotional function.

The committee then initiated a large field survey to validate the measurements of the developed instrument. From October 2009 to November 2010, subjects were recruited by 10 orthopaedic outpatient clinics nationwide after institutional review board approval from each hospital. Inclusion criteria were patients older than 60 years old with knee osteoarthritis. We excluded patients with inflammatory arthritis such as rheumatoid arthritis, gouty arthritis, ankylosing spondylitis, knee problems that required emergency treatments such as septic arthritis, and a history of trauma within 6 months. All patients provided informed consent and were administered the KKS, which was completed without a rater. Completed questionnaires were collected by the investigators on the day of the visit. Nationwide, 634 patients (70 men, 564 women) in 10 institutes participated in this survey (Table 3). Mean age (SD) of participants was 65 years (± 8 , male) and 66 years (± 8 , female). Height was 168 cm (± 6 , male) and 154 cm (± 11 , female). Weight was 70 kg (± 10 , male) and 61 kg (± 9 , female).

The visual analog scale (VAS) for pain, Oxford knee score [3], Knee Society score (KSS) [6, 12, 13], and SF-36 [14, 15] were administered concurrently to validate the KKS. To assess test-retest reliability, the KKS and VAS for pain were again administered 1 to 4 weeks later. Patient status was determined using VAS pain scores. To assess responsiveness, all previously administered instruments were rechecked after 3 months. The second survey to assess test-retest reliability included 557 participants and the third survey to assess responsiveness included 442 participants. We administered the KKS and VAS for pain during the first and second surveys. Only those subjects with the same VAS pain scores in both surveys were included in the reliability analysis (Table 4).

Two measures of reliability were evaluated: test-retest reliability and internal consistency. Test-retest reliability, often called reproducibility or repeatability, measures whether the instrument produces the same results on repeated administration to stable subjects [9] and was determined using intraclass correlation coefficients (ICCs). Internal consistency was assessed using Cronbach's alpha, which addresses the homogeneity of the questions within a questionnaire.

Table 3. Demographic data of the participants

Demographic	Mean $\pm$ SD		
	Total (N = 634)	Male (N = 70)	Female (N = 564)
Age (years)	66 $\pm$ 8	65 $\pm$ 8	66 $\pm$ 8
Height (m)	155 $\pm$ 11	168 $\pm$ 6	154 $\pm$ 11
Weight (kg)	62 $\pm$ 9	70 $\pm$ 10	61 $\pm$ 9

Responsiveness, or the ability to reflect changes in patient status, was assessed for the KKS using standardized response means calculated by the following formula: (mean postoperative score – mean preoperative score)/SD of the change in score. High responsiveness indicates a greater ability to detect changes.

The validity of an instrument is defined as “measuring what it is supposed to” [5]. Validity refers to the precision with which the true value is estimated by the questionnaire. Content validity refers to the ability of an instrument to represent all important areas of the construct of interest. The floor effect is the percentage of subjects with the lowest possible score, and the ceiling effect is the percentage of those with the highest possible score. A floor or ceiling effect of < 20% indicates reasonable content validity. The content validity of the KKS was evaluated by the distribution of final scores and represented by floor and ceiling effects. Construct validity, comprising convergent and divergent validity, reflects the explanatory power in relation to established measures. Convergent validity refers to the degree to which a measure correlates with other

theoretically correlated measures, and divergent validity refers to the degree to which a measure is not correlated with other measures with predicted noncorrelation. Because there is no gold standard evaluation tool for clinical status, previously established measures are compared with new instruments. The construct validity of the KKS was tested by calculating Pearson’s correlation coefficients with the Oxford knee score, modified Hospital for Special Surgery score, and SF-36 score.

Each item of the KKS is scored from 0 to 4 (maximum total raw score = 164); a score of 0 reflects the poorest patient status and higher scores indicate better patient status. The final score can be converted to a 100-point scale using the following formula: (KKS score/164) × 100.

Results

The KKS exhibited an ICC of 0.931 ($p < 0.01$) and internal consistency (Cronbach’s $\alpha = 0.973$). Cronbach’s alpha did not increase if the item was deleted; therefore, all items were determined to be included to the final questionnaire form (Appendix 1).

The KKSs were normally distributed with no ceiling or floor effect, reflecting content validity (Table 4). The KKS correlated with KSS knee and function scores ($r = 0.599$ and 0.690 , respectively), the Oxford knee score ($r = 0.871$), and the physical functioning, role-physical, bodily pain, and social functioning domains of the SF-36 ($r = 0.668, 0.572, 0.719$, and 0.549 , respectively). Weak correlations were obtained with the general health, role-emotional, vitality, and mental health domains of the SF-36 ($r = 0.320, 0.572, 0.402$, and 0.428 , respectively) (Table 5). The calculated standardized response mean of the KKS was 0.74 (Table 6), which was higher than that of any other instruments. When analyzed in males and females separately, the results were nearly same among the total population and in both sexes (Appendix 2).

Table 4. Measurement properties of the Korean knee score

Psychometric properties	Value
Validity	
Construct validity (correlation coefficient)	
Oxford knee score	0.871
Knee Society score	
Knee score	0.599
Function score	0.690
SF-36	
Total	0.695
General health	0.320
Physical functioning	0.668
Role-physical	0.572
Bodily pain	0.719
Vitality	0.402
Social functioning	0.549
Role-emotional	0.407
Mental health	0.428
Content validity	
Ceiling effect/floor effect	No/No
Reliability	
Internal consistency	
Cronbach’s alpha	0.973
Test-retest reliability	
Intraclass correlation coefficient	0.931
Responsiveness	
Standardized response mean	0.74

Table 5. Responsiveness of the various instruments

Instrument	Mean of change	SD	SRM
Korean knee score	21.9	29.4	0.74
Pain VAS (0–10)	2.0	3.6	0.55
KSS (knee score)	–5.6	9.2	0.61
KSS (function score)	–12.1	19.1	0.63
Oxford score	–8.9	19.6	0.46

SRM = standardized response mean = mean of change/SD of change score; VAS = visual analog scale; KSS = Knee Society score.

Table 6. Comparison of psychometric properties of the Korea knee score with the questionnaires

Questionnaires	Internal consistency (Cronbach's alpha)	Test-retest reliability	Construct validity (correlation coefficient)		Responsiveness
			Convergent validity*	Divergent validity†	
Oxford knee score [3]	0.87 to 0.93	ICC 0.92	−0.71 to −0.47	−0.25 to −0.19	Effect size 2.19
Knee Society score [12, 13]	NR	Kappa 0.26–1.00	0.31–0.72	NR	SRM 0.8–2.2
WOMAC [2]	0.73 to 0.96	Kendall's tau c statistic 0.48–0.72	NR‡	NR‡	High§
KOOS [17]	NR	ICC 0.75–0.93	0.46–0.57	0.09	Effect size, 0.84–1.65
Current study	0.973	ICC 0.931	0.549–0.719	0.407–0.428	SRM 0.74

* Convergent validity = correlation with the SF-36 physical functioning, role-physical, bodily pain, and social functioning score; †divergent validity = correlation with the SF-36 mental health and role-emotional score; ‡construct validity of WOMAC was evaluated not by SF-36 but by Lequesne system, etc; §responsiveness of WOMAC was analyzed by Student's t-test and Wilcoxon test and only p-value was reported; KOOS = Knee Injury and Osteoarthritis Outcome; ICC = intraclass correlation coefficient; SRM = standardized response mean; NR = not reported.

Discussion

Patients' perspectives on functioning and health have been increasingly recognized as a crucial aspect of health care, leading to the use of patient-reported instruments for outcome assessment. Such instruments for TKA do not reflect the floor-based lifestyle with high knee flexion of eastern Asia. The purposes of this our study were therefore to (1) describe a novel patient-generated knee evaluation instrument, the KKS, to reflect floor-based lifestyles with high knee flexion that included questions regarding HRQOL; (2) determine the reliability of the questionnaire; and (3) perform limited validation studies.

Our study is subject to some limitations. First, this new scoring system has some problematic characteristics. The questionnaire contains too many items ($n = 41$) and most patients cannot complete it in 10 minutes. Although we sought to reduce the number of items by determining impact factors and evaluating internal consistency, all items exhibited a considerable impact score and high internal consistency that did not increase by the removal of any item. Thus, we decided not to reduce the number of questionnaire items. Some items are similar such as rising from sitting, getting on/off the toilet, and rising from a sofa or low chair. We included several pictures of furniture items in the KKS administrative materials to clarify these questions. Despite these concerns, most of the patients did not show any confusion or difficulty filling out the items during the field study. Second, we validated the instrument only for patients with osteoarthritis treated nonoperatively and therefore at the present time would apply only to such patients. Additional validation research in patients with various disease and treatments would be required to ensure the questionnaire is generalizable. Third, we did not

perform multidimensional validation and the KKS could not be administered and interpreted multidimensionally. However, many other questionnaires such as IKDC, WOMAC, KOOS, and Oxford knee score are composed of multidimensions, but these measures are not commonly interpreted multidimensionally. Further study including multidimensional analysis would be needed as well.

The KKS is a patient-derived outcome measure instrument for evaluating knee osteoarthritis that was designed with particular consideration for HRQOL and, most of all, for the Korean floor-based lifestyle. In recent years, there has been wide acceptance and recognition of the importance of patient-reported outcome measures in the evaluation of patients' health status after treatment [9, 10, 18]. This is because functional status and quality of life are best described by patients rather than by physicians. Furthermore, observer-based measures show poor reliability and are poorly correlated with patient satisfaction and outcomes [11], and physicians tend to describe better patient functioning than do patients [19]. Thus, the KKS was developed as a patient-derived instrument for the assessment of treatment outcome. Several validated instruments are available for the assessment of patients with arthritis of the knee. However, the commonly used questionnaires were developed for the evaluation of Western patients and do not reflect many aspects of the East Asian lifestyle, particularly the floor-based lifestyle. For example, KSS, which is the most widely used instrument worldwide, can reflect pain, ROM, stability, walking ability, and ability to use stairs [6]. Even if one has severe difficulties living on the floor, he or she can have the highest score in the KSS system; however, with a view of quality of life, he or she has low quality of life. The

importance of HRQOL in the evaluation of patients after treatment cannot be overemphasized. The KKS was therefore designed with special emphasis on the Korean floor-based lifestyle, which requires high knee flexion during activities such as frequent kneeling and crosslegged sitting. Crosslegged sitting is possible with flexion of 135°; sitting on legs (Seiza sitting in Japan, Muslim prayer, tea ceremony in Korea, prayer in Buddhism way, and so on, commonly seen in the Eastern lifestyle) is possible with knee flexion of 150°. Standing from the floor is very difficult with the 90° of flexion [21]. This activity is not only related to the functional aspect, but also to the quality of life. People are normally happier when they can live in a traditional lifestyle in their society. The KKS contains seven new items, six of which assess the floor-based lifestyle and one of which assesses traveling. We presumed Korean patients believed knee functions related to floor lifestyle more important than other functions. The expert committee therefore generated several items of the floor lifestyle because they believed those items, which could not be found in previous questionnaires, were more essential to evaluate knee function. In the development phase of KKS, the impact score survey to 50 patients revealed items with floor-based lifestyle ranked highly. In some regions, eg, Korea, Japan, all of the population is living with a floor-based lifestyle without exception. Therefore, it is not adequate to split the population into low- and highly demanding activities according to the floor-based lifestyle in these cultural regions. Irrgang et al. [7] reported items with high flexion knee activity could differentiate knee status in the high function range and improve measurement properties of the scoring tools when used in combination with those tools. However, they did not prove whether a combined questionnaire had good psychometric properties. Our development research was a more advanced effort than that of Irrgang et al., who developed a new questionnaire system including a new subdomain and validating as one system.

The KKS showed high test-retest reliability, indicating adequate standardization and adaptation to patients. The items comprising the KKS also showed high internal consistency, and each item score showed a high correlation with the total KKS score. The Cronbach's alpha value for the total score was not increased by the removal of any individual item.

We performed limited validation studies. Content validity was confirmed by the normal distribution of the KKS responses of all 634 patients and the absence of floor and ceiling effects for all points of evaluation. The

correlation of the KKS with established scoring systems, confirming construct validity, was performed. It showed the highest correlation with the Oxford knee score ($r = 0.871$) and good correlation with the modified Hospital for Special Surgery knee and function scores ($r = 0.599$ and 0.690 , respectively). As expected, the highest correlation occurred between SF-36 and KKS scales that measured similar constructs (physical functioning, role-physical, bodily pain, and social functioning). Generally, higher correlations were detected when KKS scales were compared with SF-36 scales that measured physical health (good convergent construct validity), and lower correlations were found between KKS and SF-36 scales that measured mental health (good divergent construct validity). The KKS yielded a high standardized response mean value at 3 months (standardized response mean = 0.74), indicating it is highly responsive. This value was also higher than those of the other instruments. Such a highly responsive tool is useful for identifying small but clinically important changes after treatment and thus is useful for monitoring patients in clinical settings. Compared with other questionnaires, the KKS showed equivalent or superior measurement properties (Table 6). When validation was performed in males and females separately, all the items of psychometric properties were similar to those of the total population and to each other. This suggests the KKS can be applied to men and women similarly.

The KKS, which is a patient-derived assessment system, includes questions regarding HRQOL and reflects a floor-based lifestyle with high knee flexion and is a reliable, valid, and responsive instrument for the assessment of osteoarthritis. Our observations suggest the KKS is an appropriate method for evaluating Korean patients with osteoarthritis, especially those with a floor-based lifestyle.

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Appendices

Appendix 1. Cronbach's alpha for internal consistency

Item number	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
K 1	129.2351	1133.373	0.639	0.973
K 2	128.9248	1138.293	0.693	0.973
K 3	128.9389	1137.718	0.695	0.973
K 4	129.2868	1129.203	0.743	0.972
K 5	130.7461	1146.058	0.521	0.973
K 6	130.7555	1145.676	0.542	0.973
K 7	130.1693	1124.945	0.780	0.972
K 8	129.8339	1127.903	0.722	0.972
K 9	129.5799	1124.216	0.723	0.972
K 10	129.5987	1127.610	0.774	0.972
K 11	130.2414	1139.869	0.535	0.973
K 12	129.4718	1129.882	0.692	0.973
K 13	129.5016	1140.062	0.519	0.973
K 14	129.2759	1130.527	0.685	0.973
K 15	129.6113	1149.720	0.410	0.974
K 16	128.8636	1146.689	0.529	0.973
K 17	130.6301	1140.912	0.605	0.973
K 18	130.7774	1139.988	0.583	0.973
K 19	130.0141	1123.700	0.816	0.972
K 20	130.3480	1121.747	0.592	0.973
K 21	130.0893	1123.114	0.810	0.972
K 22	129.7853	1126.593	0.776	0.972
K 23	129.5125	1126.118	0.814	0.972
K 24	129.4639	1123.113	0.821	0.972
K 25	129.8918	1123.462	0.804	0.972
K 26	130.0031	1128.320	0.661	0.973
K 27	129.3464	1123.646	0.786	0.972
K 28	129.5972	1121.670	0.834	0.972
K 29	129.3009	1123.787	0.804	0.972
K 30	129.4796	1121.343	0.828	0.972
K 31	129.3950	1119.282	0.820	0.972
K 32	129.2288	1124.406	0.812	0.972
K 33	128.9451	1129.496	0.750	0.972
K 34	128.8871	1133.592	0.753	0.972
K 35	128.9342	1129.352	0.748	0.972
K 36	129.7633	1185.201	0.034	0.975
K 37	130.2194	1133.660	0.800	0.972
K 38	129.4122	1133.665	0.599	0.973
K 39	130.0940	1128.019	0.645	0.973
K 40	130.9013	1143.954	0.565	0.973
K 41	130.0016	1132.702	0.715	0.973

Appendix 2. Psychometric property values for all patients

Psychometric properties	Total	Male	Female
Validity			
Construct validity (correlation coefficient)			
Oxford knee score	0.871	0.896	0.864
Knee Society score			
Knee score	0.599	0.519	0.600
Function score	0.690	0.748	0.674
SF-36			
Total	0.695	0.619	0.707
General health	0.320	0.320	0.293
Physical functioning	0.668	0.607	0.671
Role-physical	0.572	0.505	0.585
Bodily pain	0.719	0.646	0.726
Vitality	0.402	0.415	0.397
Social functioning	0.549	0.461	0.567
Role-emotional	0.407	0.337	0.428
Mental health	0.428	0.429	0.427
Content validity			
Ceiling effect/floor effect	No/No	No/No	No/No
Reliability			
Internal consistency			
Cronbach's alpha	0.973	0.974	0.973
Test-retest reliability			
Intraclass correlation coefficient	0.931	0.943	0.925
Responsiveness			
Standardized response mean	0.74	0.73	0.74

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