Usefulness of the Korean Knee Score for Evaluation of the Results of Total Knee Arthroplasty

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Purpose: The Korean Knee score (KKS) was designed to reflect the floor-sitting lifestyle that necessitates high knee flexion. The purpose of this study is to assess whether the KKS reflects the floor-sitting lifestyle more accurately than the previously developed Knee Society clinical rating system. In addition, the presence of ceiling effects was compared between the two rating systems.

Materials and Methods: Eighty-one consecutive patients (120 knees) who were assessed regularly after total knee arthroplasty (TKA) on an outpatient basis between January 2012 and December 2012 were enrolled. All patients were asked to complete a questionnaire to assess the Knee Society Knee score (KSKS), Knee Society Function score (KSFS), and KKS.

Results: At the final follow-up, the mean KSKS, KSFS, and KKS were 91.2, 86.0, and 70.1, respectively, and the scores were similar between the ≥125° maximum flexion group and <125° maximum flexion group. However, the ‘floor life’ subdomain score of the KKS was significantly higher in the >125° maximum flexion group (15.13 vs. 11.24, p=0.001). The number of cases with the highest possible score was 24 (20%) for the KSKS and 47 (39%) for the KSFS, whereas none of the cases obtained the highest possible KKS. According to the standard deviation method, more substantial ceiling effects were present in the KSKS (83 cases, 69.1%) and KSFS (67 cases, 55.8%) than in the KKS (23 cases, 19.2%).

Conclusions: Although the KKS was effective in reducing the ceiling effect, it demonstrated limited improvement in assessing the ability to perform high knee flexion after TKA. However, the ‘floor life’ subdomain of KSS appeared to be valid for evaluating high flexion of the knee.

Keywords: Knee, Arthroplasty, Korean knee score, Ceiling effect, High flexion, Floor life

Introduction

Total knee arthroplasty (TKA) has been recognized as a successful surgical procedure for the treatment of knee arthritis refractory to conservative therapy. Although TKA has been associated with favorable objective outcomes and high patient satisfaction, efforts have been continuously made to improve objectivity in the clinical assessment of postoperative results by developing multiple scoring systems. Such systems assign a point value for each assessment item, mainly pain, range of motion, joint stability, deformity, and joint contracture, for preoperative and postoperative evaluation in TKA patients. However, various studies have suggested that there is some discrepancy between the clinical results obtained by scoring systems and patient’s satisfaction and functional outcome. In particular, the presence of ceiling effects in some scoring systems may affect their reliability as valid evaluation tools.

The Knee Society Knee score (KSKS) and Knee Society Function score (KSFS) are most commonly used for the assessment of the knee joint; however, they may not be reliable for the assessment of the ability to perform high flexion in Korean patients who are expected to sit on the floor more often than westerners. Patients with limited range of flexion have difficulty in sitting cross-legged on the floor or standing up from sitting position on the floor. Ueo et al. suggested ≥120° of flexion should be achieved to resume the floor-sitting lifestyle after TKA. Choi et al. reported that the most common complaints among Korean patients after TKA were the difficulty of standing up from the
### Table 1. Korean Knee Score

| Items                                                                 | Scores (4–0)                                                                 |
|---------------------------------------------------------------------|---------------------------------------------------------------------------|
| **1. Pain & symptoms**                                               |                                                                           |
| 1) Pain during sleep                                                | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 2) Pain on sitting or lying                                          | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 3) Pain on standing                                                 | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 4) Pain on stair climbing                                            | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 5) Pain during walking                                              | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 6) Morning stiffness                                                | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 7) Afternoon stiffness on sitting, lying, and resting                | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 8) Pain on maximum knee flexion                                     | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 9) Knee swelling                                                    | □ Never □ Rarely □ Sometimes □ Often □ Always                              |
| 10) Pain on maximum knee extension                                  | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 11) Grinding, clicking, or other noise from the knee                 | □ Never □ Rarely □ Sometimes □ Often □ Always                              |
| 12) Locking (inability to bend or straighten the knee)               | □ Never □ Rarely □ Sometimes □ Often □ Always                              |
| **2. Function**                                                     |                                                                           |
| 13) Difficulty performing heavy household chores (e.g. house cleaning, maintenance, heavy laundry) | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 14) Difficulty in getting on/off a vehicle                          | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 15) Difficulty in descending stairs                                 | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 16) Difficulty in ascending stairs                                  | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 17) Difficulty performing light household chores (e.g. light house cleaning, dishwashing, laundry) | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 18) Difficulty in rising from sitting                              | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 19) Difficulty performing grocery shopping                          | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 20) Difficulty in bending down                                       | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 21) Difficulty in standing                                          | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 22) Difficulty in walking                                           | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 23) Difficulty in getting on/off toilet                             | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 24) Difficulty in getting in and out of bath                        | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 25) Difficulty in rising from bed                                   | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 26) Difficulty in lying in bed                                      | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 27) Difficulty in putting on socks or pantyhose                     | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 28) Difficulty in taking off socks or pantyhose                     | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 29) Difficulty in sitting on a chair                               | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| **3. Evaluation of floor life**                                     |                                                                           |
| 30) Pain on kneeling (e.g. for bowing or praying)                   | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 31) Pain on squatting                                               | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 32) Pain on making a bed on the floor                               | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 33) Pain on sitting with crossed legs                               | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 34) Pain on squatting with legs crossed                             | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 35) Pain on rising from a low chair                                 | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| **4. Socio-emotional function**                                     |                                                                           |
| 36) Efforts at lifestyle modification to avoid knee straining activities | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 37) General discomfort in the knee                                  | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 38) Difficulty with social relationships (with family members, friends, and neighbors) due to physical or emotional reasons in the past one month | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
| 39) Reluctance to travel due to the knee                            | □ Never □ Once per month □ Once per week                                   |
| 40) Frequency of awareness of the knee joint problem                | □ Once per day □ Always                                                   |
| 41) Difficulty due to lack of confidence in the knee                | □ None □ Mild □ Moderate □ Severe □ Extreme                                |
floor which often requires the support of the hands and insufficient range of high flexion. In an attempt to overcome the limitations of the KSKS and KSFS in assessing Korean TKA patients with the floor-sitting lifestyle, the Korean Knee Society devised the Korean Knee score (KKS) system designed to accommodate the evaluation of high flexion after TKA in 2009. Ha et al.9 described it as an effective scoring system with high specificity and sensitivity.

The purpose of this study is to investigate whether the KKS system is useful for evaluating the ability to perform high flexion after TKA and reducing the ceiling effect compared to the KSKS and KSFS.

Materials and Methods

Of the patients who underwent outpatient evaluation after TKA between January 2012 and December 2012, those who were available for a minimum 1-year follow-up were retrospectively reviewed. The patients were asked to complete a questionnaire during an outpatient visit. The exclusion criteria were suspected postoperative infection and cognitive inability to understand the questionnaire. The total number of patients was 81 (male: 4, female: 77; 120 knees) with a mean age of 69 years (range, 51 to 86 years). The operated side was the right side in 64 knees and the left side in 56 knees. The preoperative diagnosis was degenerative osteoarthritis in 106 knees and rheumatoid arthritis in 14 knees. The surgery was bilateral in 39 patients and unilateral in 42 patients. The mean follow-up period was 33 months (range, 13 to 65 months). In all knees, a posterior cruciate ligament substituting implant was used: Scorpio NRG (Stryker, Mahwah, NJ, USA) in 42 knees; NexGen LPS (Zimmer Inc., Warsaw, IN, USA) in 46 knees; PFC Sigma (Johnson & Johnson, Raynham, MA, USA) in 21 knees; and Optetrak (Exactech Inc., Gainesville, FL, USA) in 11 knees.

Postoperative assessments were performed using the clinical rating system of the American Knee Society (KSKS and KSFS) and the KKS.3,8 The American Knee Society clinical rating system consists of the knee score and function score and the scores range from 0 to 100 points. The KSKS evaluates pain, range of knee motion, stability, flexion contracture, extension lag, and alignment, whereas the KSFS evaluates walking distance, stair climbing ability, and use of walking aid.

The KKS is composed of four subdomains (41 items): 1) pain and symptoms (12 items); 2) function (17 items); 3) evaluation of floor life (6 items); and 4) socio-emotional function (6 items). Each item can be scored up to 4 points and the total score is converted to a 100-point scale for evaluation (Table 1).

The presence of a ceiling effect was determined according to the method of McHorney and Tarlov (≥15% of the patients scored the highest possible points) and the standard deviation method (the proportion of cases with points greater than the highest possible point minus the value of standard deviation) and the percentages of cases that meet both definitions of ceiling effect were calculated for each scoring system. The Kolmogorov-Smirnov test was used to evaluate the null hypothesis that the assessment results would follow a normal distribution.

Considering that the knee with ≥125° of flexion is awarded the highest possible point on the range of flexion assessment in the American Knee Society clinical rating system, we divided the patients into those with ≥125° of maximum range of flexion (high flexion group) and those with <125° of maximum range of flexion (non-high flexion group) and investigated intergroup differences in the KSKS, KSFS, and KKS. In addition, the high flexion group and the non-high flexion group were compared with regard to the scores for four subdomains of the KKS system.

Statistical analysis was performed using the SAS ver. 9.2 (SAS Institute Inc., Cary, NC, USA). The Wilcoxon rank sum test was used with the statistical significance set at p<0.05.

Results

In the total 120 knees, the mean KSKS was 91.2 points (range, 50 to 100 points), the mean KSFS was 86.0 points (range, 30 to 100 points), and the mean KKS was 70.1 points (range, 25 to 99 points) (Table 1).

On the ceiling effect analysis, the percentage of knees with the highest possible KSKS was 24 knees (20%) and that with the highest possible KSFS was 47 knees (39%), indicating the presence of ceiling effects for the two scoring systems. On the other hand, there was no case with the highest possible score for the KKS. However, when assessed according to the standard devia-

| Variable | KSFS | KSFS | KKS |
|----------|------|------|-----|
| ROM (°)  | ≥125 (n=90) | 91.7±9.2 | 85.5±16.4 | 70.7±15.5 |
|          | <125 (n=30) | 89.7±10.4 | 84.7±12.2 | 68.5±16.9 |
| Total (n=120) | 91.2±9.5 | 86.0±15.3 | 70.1±15.7 |

Values are presented as mean±standard deviation.
KSFS: Knee Society Function score, KSKS: Knee Society Knee score, KKS: Korean Knee score, ROM: range of motion.
tion method, profound ceiling effects were observed: in 83 knees (69.1%) for the KSKS, 67 knees (55.8%) for the KSFS, and 23 knees (19.2%) for the KKS (Table 3).

The histogram of the distribution of points for the three different scoring systems showed a normal distribution curve for the KKS, whereas the curve was skewed to the right (negatively skewed distribution) for the KSKS and KSFS (Fig. 1).

| Scoring system | Method            | Standard deviation |
|----------------|-------------------|--------------------|
| KSKS           | 20 (24)           | 69.1 (83)          |
| KSFS           | 39 (47)           | 55.8 (67)          |
| KKS            | 0 (0)             | 19.2 (23)          |

Values are presented as percentage (number).

Table 3. Ceiling Effects of Each Scoring System

Fig. 1. Frequency distribution of the Knee Society Knee score (KSKS) (A), Knee Society Function score (KSFS) (B), and Korean Knee score (KKS) (C).

There was no notable change in the shape of the distribution for each scoring system when the patients were subdivided into two groups according to the maximum knee flexion (Fig. 2).

On the Kolmogorov-Smirnov test for normal distribution, the null hypothesis was rejected for the KSKS and KSFS (p<0.001), and thus the two scoring systems were not found to follow a normal distribution. The KKS was found to conform to a normal distribution (p=0.087).

In the 90 knees with ≥125° maximum knee flexion, the mean KSKS was 91.7 points (range, 50 to 100 points), the mean KSFS was 85.5 points (range, 30 to 100 points), and the mean KKS was 70.7 points (range, 38 to 99 points). In the 30 knees with <125° maximum knee flexion, the mean KSKS was 89.7 points (range, 64 to 95 points), the mean KSFS was 84.7 points (range, 60 to 100 points), and the mean KKS was 68.5 points (range, 25 to 97 points). There was no statistically significant intergroup difference with regard to the KSKS (p=0.310), KSFS (p=0.541), and KKS (p=0.496) (Table 4).
The scatter plots for the comparison of the KSKS and KKS and the KSFS and KKS displayed a wide distribution pattern for the KKS system, as opposed to those of the KSKS and KSFS where the majority of points were concentrated in the upper-right corner, indicating the presence of ceiling effects (Fig. 3).

Regarding the subdomains of the KKS system, no statistically significant difference between the high flexion group (n=90) and the non-high flexion group (n=30) was observed in the evaluation of pain and symptoms (mean value, 36.2 points vs. 38.2 points; p=0.238), function (mean value, 50.3 points vs. 51.4 points; p=0.835), and socio-emotional function (mean value, 16.5 points vs. 15.9 points; p=0.624) except for the floor life evaluation (mean value, 15.1 points vs. 11.2 points; p=0.001) (Table 5).

**Table 4. Analysis of Each Scoring System in Regard to Range of Motion (ROM)**

| Scoring system | ROM (°) | ≥125 (n=90) | <125 (n=30) | p-value |
|----------------|---------|-------------|-------------|---------|
| KSKS           | 91.7±9.2| 89.7±10.4   | 0.310       |
| KSFS           | 85.5±16.4| 84.7±12.2   | 0.541       |
| KKS            | 70.7±15.5| 68.5±16.9   | 0.496       |

Values are presented as mean±standard deviation.
KSKS: Knee Society Knee score, KSFS: Knee Society Function score, KKS: Korean Knee score.

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**Discussion**

TKA provides satisfactory outcomes in terms of pain relief and functional improvement, especially in patients with degenerative osteoarthritis or rheumatoid arthritis of the knee. Studies have shown that recent TKA implants offer superior longevity of minimum 20 years and demonstrate remarkable efficacy11-14. Currently, various scoring systems are available for the assessment of postoperative clinical outcomes. Of those, the KSKS and KSFS...
have been preferred by orthopedic surgeons and employed in research since Insall et al. introduced the clinical rating system.

The outcomes of TKA are assessed with respect to pain, range of motion, knee function, and joint abnormality on radiography. Of these, objective parameters, such as range of motion, joint stability, and radiographic alignment, are of particular interest to orthopedic surgeons, whereas patients are more concerned about function and tend to make more subjective assessments, which results in some disagreement in the evaluation of treatment outcomes. However, the focus of postoperative assessment has recently been shifted from joint abnormality to functional improvement. In this respect, the patient-derived KKS system can be more useful than the physician-derived KSKS and KSFS systems. Lingard et al. suggested that the Western Ontario and McMaster Universities Arthritis Index and Short Form-36 could be more effective than the KSKS and KSFS in the assessment of TKA outcomes. Likewise, the efficacy of KSKS and KSFS has been questioned by some research. In particular, it has been noted that the clinical rating system exhibits ceiling effects: it does not reflect subjective and functional discomfort experienced during sitting on the floor or standing up from the sitting position by patients from countries where high flexion position is often unavoidable due to the floor-sitting lifestyle. In the current study, the KKS demonstrated less ceiling effects than the KSKS and KSFS; therefore, we believe that the KKS would be useful for eliminating ceiling effects. On the other hand, there was no statistically significant difference in the KKS between the high flexion group and the non-high flexion group. It is our understanding that the KKS may not be effective in reflecting the level of activities demanding high flexion. However, on the assessment of the KKS subdomains, a significant intergroup difference was observed in the floor life evaluation. Thus, we believe that the floor life subdomain of the KKS can be used as a predictor of postoperative knee flexion. Although we suggest that the accuracy of postoperative evaluation can be improved by using scores for each subdomain separately than using the sum of the scores for all subdomains, this should be verified in further studies involving larger study populations.

Table 5. Analysis of Each Assessment Category of Korean Knee Score (KKS) in Regard to Range of Motion (ROM)

| Assessment category (range)         | ROM (°)                  | p-value |
|------------------------------------|--------------------------|---------|
|                                    | ≥125 (n=90)              | <125 (n=30) |         |
| Evaluation of floor life (0–24)    | 15.1±5.5                 | 11.2±5.9  | 0.001   |
| Pain and symptom (0–48)            | 36.2±8.1                 | 38.2±7.4  | 0.238   |
| Function (0–68)                    | 50.3±13.3                | 51.4±10.9 | 0.835   |
| Socio-emotional function (0–24)    | 16.5±4.7                 | 15.9±4.5  | 0.502   |

Values are presented as mean±standard deviation.
The limitations of this study are the following: 1) selection bias could have occurred by including the outpatient clinic cases only; 2) the influence of the degree of improvement and preoperative status on the outcome was not addressed due to the lack of comparison between the preoperative and postoperative KSKS, KSFS, and KKS; and 3) 125° knee flexion was used as the reference standard for high flexion, which we thought appropriate considering that the highest possible point is awarded for the knee with ≥125° flexion according to the KSKS.

Conclusions

The KKS was effective in eliminating ceiling effects that occur at high rates for the KSKS and KSFS of the clinical rating system. However, it demonstrated limited efficacy in reflecting the postoperative level of activity when the sum of the scores for all subdomains were used for evaluation. Considering that the floor life evaluation subdomain was useful in assessing the ability to perform high flexion, we recommend using scores for each subdomain separately to improve the evaluation accuracy.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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