The Journal of Arthroplasty 31 (2016) 87–91

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Are the Current Outcome Measurement Tools Appropriate for the Evaluation of the Knee Status in Deep Flexion Range?

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ARTICLE INFO

Article history:
Received 20 November 2014
Accepted 6 July 2015

Keywords:
outcome
measurement tool
appropriateness
deep flexion range
total knee arthroplasty

ABSTRACT

We determined whether current outcome measurement tools are appropriate for the evaluation of the knee status in deep flexion range after TKA. Patients (n = 604) with more than 120° of knee flexion were evaluated by Knee Society score, WOMAC, and high flexion knee score (HFKS). The appropriateness of measurement tools was analyzed by correlation analyses and group comparisons (group 1: 120°–129°, group 2: 130°–139°, group 3: 140°–150°). HFKS showed stronger correlation with knee flexion compared with other scores. While other scores only differentiated between groups 2 and 3, HFKS could differentiate among groups 1, 2 and 3. These findings suggest that employment of proper outcome measurement tool is needed to evaluate and differentiate the knee status in deep flexion range after TKA.

The employment of an appropriate outcome measurement tool is crucial for the proper evaluation of any interventions. In addition, it has been reported that the clinical outcome of total knee arthroplasty (TKA) is dependent upon the evaluation method employed [1]. Although pain relief and restoration of joint function are still the primary goals of TKA surgery, patient's expectations to be able to carry out more demanding activities such as sports participation or high flexion activities following TKA have continued to grow. Mancuso *et al*, [2] reported recreational and sports activities were ranked fifth and sixth place out of seventeen options on an expectations survey. Another study reported that dissatisfied patients after TKA tend to perceive functional disabilities in high flexion activities to be more important [3]. Moreover, there have been controversies regarding the benefits of high flexion TKA [4,5]. Therefore, a proper outcome measurement tool that differentiates between the different functional statuses in deep flexion range will be important for future clinical research.

There are various tools currently used for the evaluation of outcomes following TKA. However, it has not yet been well-investigated whether these tools are appropriate for the evaluation of the knee in deep flexion range. There have been a few tools popularly used for the evaluation of the outcome after TKA; the American Knee Society Knee Score (KSKS), the Knee Society Function Score (KSFS), and the Western Ontario and McMaster Universities Arthritis Index (WOMAC). The KSKS and KSFS are known to have ceiling effect, and accordingly, they may not be appropriate in assessing or differentiating the knee status in deep flexion range [6–8]. The WOMAC index is a disease-specific measurement tool composed of three categories; pain, stiffness, and function [9], which has been well-validated and addresses the activities of daily living [10]. However, the WOMAC may not be adequate enough to differentiate the functional differences in deep flexion range [1], and also has ceiling effect [11,12]. The high flexion knee score (HFKS) is a recently reported evaluation tool to assess the knee status in high flexion activities, which is composed of two categories; pain and function [8]. In a previous study, HFKS was known to eliminate the ceiling effect [8], however it was not investigated whether the HFKS could differentiate well between the different functional statuses of the knee in deep flexion range.

Therefore, in the present study, we intend to determine which measurement tool suitably reflects the different knee statuses related to the degree of deep knee flexion, and which measurement tool properly differentiates between the different functional statuses of the knee in deep flexion range following TKA.

Patients and Methods

We prospectively collected data on 1014 consecutive knees in 741 patients who underwent TKA between September 2007 and December 2011. Among these, 953 knees (658 patients) had more than 120° of knee flexion after the TKA. 39 knees (37 patients) were not followed-up, and consequently, the HFKS was available in 914 knees (621 patients). The minimum follow-up period was 2 years. In bilateral cases,

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.07.015.

This study was approved by institutional review board of Samsung Medical Center (IRB file No.2013-09-002-001). We attached the IRB approval as a separated file.

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http://dx.doi.org/10.1016/j.arth.2015.07.015
0883-5403/

one of the knees (left or right knee) was selected for this study by random sampling, thus leaving 621 knees. Of these, 17 knees were excluded (6 knees with a history of infection and 11 cases of revision TKA), which finally left 604 knees of 604 patients for the present study cohort. There were 566 females and 38 males with a mean age of 66 years (range, 27–83), a mean body mass index of 26.7 k/m^2 (range, 19.1–41.0 k/m^2), and a mean preoperative knee flexion of 131.6° (range, 100°–150°). The preoperative diagnoses were osteoarthritis in 598 patients (99.0%), rheumatoid arthritis in 5 (0.8%), and osteonecrosis of the medial condyle in 1 (0.2%). The mean follow-up period was 3.7 years (range, 2–6.8 years). This study was approved by the institutional review board at our institution.

The senior author of the present study performed all the TKAs using a standard technique with a medial para-patellar approach for every case. An intra-medullary alignment guide and the anterior referencing technique were used for preparation of the femur, and an extra-medullary alignment guide was used for the preparation of the tibia. The medial third of the tibial tubercle and tibial crest were used as a reference for the rotational alignment of the tibial component. The patella tracking was checked intra-operatively with trial components in place using the towel clip technique [13]. The patella was not resurfaced in this cohort. All the components were fixed with cement in every case. The Triathlon prostheses (Stryker, Mahwah, NJ, USA) were used in 214 knees, the Genesis II (Smith & Nephew, Memphis, TN, USA) in 153 knees, the LPS-flex (Zimmer, Warsaw, IN, USA) in 148 knees and the Vanguard (Biomet, Warsaw, IN, USA) in 89 knees. The reason for this mixture was principally due to logistics and contractual issues. There were no differences in the clinical outcomes among the different implants (unpublished data).

All patients underwent the same postoperative management protocol, and were encouraged to perform quadricep-setting and straight leg-raising exercises immediately after surgery. On the second postoperative day, the compression dressing and hemovac drainage were removed and the patients began tolerable weight-bearing ambulation with walking aids. Additionally, a continuous passive motion machine was applied, and active and assisted knee flexion was encouraged. Aggressive pain control was performed using a combination of oral analgesics and intravenous patient-controlled analgesia. The progression of knee flexion was checked regularly with the goal of achieving more than 120° of knee flexion without flexion contracture at an early postoperative period. Patients routinely utilized walking aids for 4 weeks until the quadricep muscle power was restored. Wearing graduated compressive stockings was recommended for 3 months postoperatively.

Patients were seen at routine follow-up visits at 6 weeks, 3 months, 6 months, 1 year after surgery, and annually thereafter. At each visit, the patient's knees were examined for alignment, stability, quadricep muscle strength, and any signs of joint abnormalities. Passive, non-weight-bearing range of motion (ROM) was also measured to the nearest 5° using a goniometer with the patient in the supine position, and was recorded in the medical records and database. Mediolateral stability was evaluated by manually-applied stresses in full extension and 30° of knee flexion at each follow-up visit, and was recorded in the medical records. One independent experienced research assistant obtained the KSKS, KSFS [14], WOMAC [10], and HFKS [8]. These four outcome measurement tools were evaluated in each patient.

To investigate which measurement tool well reflects the different degrees of deep knee flexion, the relationship between the scores of the various outcome measurement tools and the degree of deep knee flexion in each case was explored using partial correlation analysis. Subsequently, pair-wise comparisons among the correlation coefficients were performed using the Williams' test, in order to find the tool that most suitably reflects the different degrees of deep knee flexion.

To investigate which measurement tool properly differentiates the different functional status of knees in deep flexion range after TKA, in other words to compare the appropriateness of four current outcome measurement tools in each patient, the cohort of the present study was stratified into three groups by 10° increments of the amount of flexion from 120°: group 1 (120–129°), group 2 (130–139°), and group 3 (140–150°). Among the 604 patients, 183 were stratified as group 1, 186 as group 2, and 235 as group 3. Subsequently, the scores generated by the four measurement tools for each group were analyzed by multivariable median regression analyses, to correct for possible confounders. After the analyses were carried out among the 3 groups regarding the differences in clinical outcomes, a post-hoc test was performed using a median regression model. The significance level was set at a P value of 0.05. All the statistical analyses were performed by an independent professional statistician using SAS 9.3 (SAS Institute, Cary, NC, USA).

Results

Among the outcome measurement tools included in the present study, KSKS, KSFS, WOMAC and HFKS function scores showed a significant correlation with the degree of deep knee flexion ($P < 0.05$) (Table 1). Among these, the HFKS function score showed a much stronger correlation with the degree of deep knee flexion ($r = 0.411$) when compared with the other scores (KSKS, $r = 0.335$; KSFS, $r = 0.170$; and WOMAC, $r = -0.245$) (Table 1). The pain scores (WOMAC and HFKS) had no significant correlation with the degree of deep knee flexion ($P > 0.05$) (Table 1). The pair-wise comparisons among the correlation coefficients, to assess the difference in the outcome measurement tools, also demonstrated that only the HFKS function score showed a significant difference when compared with each of the other evaluation tools (Table 2).

The investigation into which measurement tool properly differentiates between the different functional statuses of knees in deep flexion range after TKA, using the 3 groups stratified by the degree of deep knee flexion, revealed that the HFKS function score showed significant differences in the comparison among group 1, group 2 and group 3 ($P < 0.001$) (Fig. 1A). However, the KSKS, KSFS, and WOMAC function scores showed a significant difference only between group 2 and group 3 ($P < 0.001$) (Fig. 1B–D, respectively). The WOMAC pain score, the WOMAC stiffness score and the HFKS pain score did not show any significant differences between the groups ($P = 0.744$, $P = 0.726$, $P > 0.999$, respectively) (Table 3).

No patients showed instability on the manual valgus–varus stress test of the knee, and no other specific complications related to deep flexion were observed.

Discussion

Although numerous measurement tools for the outcome evaluation of TKA exist [8,10,14], the majority of them do not seem to contain the necessary attributes to differentiate the functional status of the knee joint in deep flexion range. ROM is an important factor for assessing the outcome after TKA [15], and greater flexion may result in a better

Table 1
Results of Correlation Analyses Between the Various Evaluation Tools and the Degree of Deep Knee Flexion.

Outcome Measure	Correlation Coefficient	*P* Value
Knee Society score		
Knee	0.335	<0.001
Function	0.170	<0.001
WOMAC[a]		
Pain	0.048	0.710
Stiffness	−0.036	>0.999
Function	−0.245	<0.001
HFKS[b]		
Pain	0.041	0.631
Function	0.411	<0.001

KSKS, Knee Society knee score; KSFS, Knee Society function score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; HFKS, high flexion knee score.
[a] The level of Bonferroni's correction was 3.
[b] The level of Bonferroni's correction was 2.