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# A Comparison of Patient-Reported and Measured Range of Motion in a Cohort of Total Knee Arthroplasty Patients

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ABSTRACT

Range of motion (ROM) is an important component of the assessment of total knee arthroplasty (TKA) outcome. We compared patient-reported versus clinically observed ROM in a prospective cohort. Clinically observed ROM was measured using a goniometer by a trained research assistant. Self-reported ROM was estimated using a set of lateral knee photographs depicting varying levels of flexion and extension. All measures were taken pre-operatively, three, and six months postoperatively. We found statistically significant associations between self-reported ROM and clinically observed ROM for flexion and extension (all $P < 0.001$). We dichotomized flexion at 90° and found that self-report had a specificity of 94% and sensitivity of 65%. We conclude that patient-reported ROM may be a useful outcome measure for TKA.



Total knee arthroplasty (TKA) is commonly utilized to improve pain and function in persons with advanced knee osteoarthritis (OA), with over 600,000 procedures performed annually in the US [1]. Approximately 97% of TKAs are performed for knee osteoarthritis [2]. The procedure is remarkably successful, with about 80% of TKA recipients experiencing substantial pain relief and functional improvement [3,4].

Advanced knee OA is typically associated with reduced knee range of motion (ROM), which in turn heightens the disability and functional limitations of knee OA [5–9]. Individuals who cannot flex greater than 90° or extend to a neutral position may experience difficulty with routine activities such as rising from chairs or walking. One of the goals of TKA is to restore ROM to a functional range [10]. Given its functional importance, knee ROM is a crucial component of preoperative and postoperative assessment in patients undergoing TKA. In fact, ROM is an important component of the American Knee Society Score [11]. One study of patients undergoing TKA found that both preoperative and 12-month knee flexion had modest associations with 12-month function. In addition, at 12 months patients with less than 95° of flexion had significantly worse function than patients with greater than 95° of flexion [12].

Traditionally, ROM is measured by a clinician or trained researcher. The need for direct measurement renders assessment of ROM more logistically complex and resource intensive than assessment of pain and health status, which can be elicited with self-report measures administered by phone or mail. One approach to this problem is patient self-assessment of ROM. Recently Gioe et al developed a method that presents patients a set of lateral knee photographs depicting varying levels of flexion and extension and asks patients to select the photographs that most closely resemble their motion [13]. The authors compared this patient self-reported ROM with physician measurements in a cross sectional study of patients at least one year post-TKA and concluded that patient-reported ROM was sufficiently accurate for use in long-term surveillance after TKA [13].

A study by Khanna and colleagues also concluded that knee ROM could be accurately reported by patients based on photographs [14]. This study also reported that patient self-assessment using a goniometer was not superior to assessment with photographs. Neither Khanna et al nor Gioe et al compared patient-reported ROM before and after TKA.

In this study, we aimed to compare this self-reported method of assessing flexion and extension with clinical measurement before and after TKA. Our goal was to validate the findings of Gioe et al and Khanna et al in an independent sample and to extend these findings to a prospective cohort permitting evaluation of change in ROM over time.

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## Materials and Methods

### Sample

This study was conducted as part of a prospective cohort study of consecutive patients undergoing TKA by five orthopedic surgeons at a tertiary medical center. Patients were enrolled between August 2010 and May 2011. Eligible patients were aged 40 years or older, had a primary diagnosis of OA and spoke English. Patients with a diagnosis of inflammatory arthritis, those who lived in a nursing home, and those with plans for additional elective surgery within 6 months were excluded. A research assistant screened surgeons' schedules for eligible patients, who were then invited to participate. This study was approved by the Institutional Review Board.

### Data Collection

Subjects were assessed pre-operatively at baseline and at 3 and 6 months post-operatively. Baseline visits were completed in person. Patients were given the option to complete the post-operative visits in person or to mail in a study survey. In-person visits included a physical exam performed by a trained research assistant (RA), including measurement of active ROM using a goniometer. Research assistants underwent intensive knee examination training either by the lead Physical Therapist or by the study Co-Investigator, a Rheumatologist. Approval was required prior to permitting the RA's independent examination of the patient, and RA competency was evaluated and documented annually. We did not have access to an examining table, so flexion measurements were taken with patients seated in a portable wheelchair and extension measurements were obtained with patients standing. We examined feasibility, reliability, and comfort using various types of chairs for persons of different height and body habitus. We found that a portable wheelchair was best in terms of standardization as well as the fidelity of the data, though we found no discernible differences between the various types of chairs. The seat of the wheelchair was approximately 18 inches high and 18 inches deep and was not cushioned. As a part of the study questionnaires, patients were asked to self-report flexion and extension on their operated knee using the method of Gioe et al in which study participants were presented with pictures of knees positioned at varying levels of flexion and extension [13]. The pictures show the knees in seated position. Six pictures show flexion ranging from 80° to >120° in increments of 10°. Four pictures show extension ranging from completely straight to >20° from straight. The questionnaires also assessed demographic information as well as level of pain and function using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) [15].

### Statistical Analysis

We compared demographic and clinical features of patients who completed in-person versus mail-in follow-up visits to ensure that there were no differences in the two groups. We expressed flexion as degrees of flexion beyond neutral and extension as the degrees of flexion contracture (failure to reach neutral). Thus, greater 'extension' reported in this paper represents greater contracture and higher numbers reflect worse status. We examined associations between clinically observed ROM as measured by the RA and self-reported ROM as captured in the photographs. First, we tested whether mean RA-measured ROM differed by patient-reported category using ANOVA. Then we modeled patient-reported ROM as an ordinal variable to investigate for linear trend.

We considered poor flexion to be a measurement of less than 90° [12,16]. We dichotomized measured flexion as less than or greater than 90° and compared this to the self-reported category to determine the sensitivity and specificity of patient self-assessment of poor flexion. Confidence intervals were adjusted to account for clustering within patients [17].

For both flexion and extension we grouped patients based on change from baseline in self-reported ROM into categories of improved, no change, and worsened. For flexion, improvement was defined as having a higher self-reported category (greater flexion) at follow-up as compared to baseline, while for extension a lower self-reported category (less contracture) was considered improvement. We evaluated the mean change in measured flexion and extension for each of the three categories. We did this separately at 3 and 6 months.

Data were collected and managed using REDCap electronic data capture tools hosted by Partners HealthCare Research Computing, Enterprise Research Infrastructure & Services (ERIS) group [18]. All analyses were conducted in SAS v9.3 (SAS Inc., Carry, NC).

## Results

### Baseline Cohort Characteristics

One hundred and sixteen patients signed consent and were enrolled into the study. For the purposes of this study, we excluded 3 patients who underwent simultaneous bilateral TKA and 1 patient who did not complete a baseline questionnaire; thus, 112 patients were included in the analysis. Among these individuals all patients completed a baseline questionnaire (100 with both objective ROM measurement by a research assistant as well as self-rated ROM), 98 completed a 3-month questionnaire (62 with both objective ROM measurement and self-rated ROM), and 94 completed a 6-month questionnaire (53 with objective ROM measurement and self-rated ROM). The mean age of the cohort at baseline was 64.8 years (SD 8.9), 52% were female, and 91% were White (Table 1). The mean pre-operative WOMAC pain and function scores were 42.6 (SD 17.7) and 44.2 (SD 15.4) respectively (scaled from 0 to 100; 100 worst).

### Comparison of Patients With and Without ROM Measured

Patients with objective ROM measurements at follow-up (in-person visits) were similar to patients without objective ROM measurements with respect to age, WOMAC (at baseline and at the follow-up visit when ROM was assessed), and self-rated flexion and extension. Baseline objectively measured ROM was also comparable. For example, patients with objectively measured ROM at month 3 had a mean baseline flexion of 110.2 (SD 13.2) compared to a mean baseline flexion of 109.2 (SD 11.6) in the group that did not have ROM objectively measured at month 3 (please refer to the supplementary appendix for more information).

**Table 1**
Baseline Characteristics of Cohort.

| Characteristic | Statistic |
|---|---|
| Mean Age (SD) | 64.8 (8.9) |
| Mean BMI (SD) | 31.2 (6.5) |
| Gender, n (%) | |
| Male | 54 (48.2%) |
| Female | 58 (51.8%) |
| Race, n (%) | |
| Non-White | 10 (9.1%) |
| White | 100 (90.9%) |
| Surgeon, n (%) | |
| 1 | 22 (19.6%) |
| 2 | 6 (5.4%) |
| 3 | 17 (15.2%) |
| 4 | 47 (42.0%) |
| 5 | 20 (17.9%) |
| Mean WOMAC Pain[a] (SD) | 42.6 (17.7) |
| Mean WOMAC Function[a] (SD) | 44.2 (15.4) |

[a] Scaled from 0 to 100; 100 is worst.