Joint awareness after total knee arthroplasty is affected by pain and quadriceps strength

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ARTICLE INFO

Article history:
Received 24 October 2015
Accepted 24 February 2016

Keywords:
Total knee arthroplasty
Joint awareness
Patient-reported outcome
Forgotten joint score

ABSTRACT

Introduction: There is a growing interest in the use of patient-reported outcomes to provide a more patient-centered view on treatment. Forgetting the artificial joint can be regarded as the goal in joint arthroplasty. The goals of the study were to describe changes in joint awareness in the artificial joint after total knee arthroplasty (TKA), and to determine which factors among pain, knee range of motion (ROM), quadriceps strength, and functional ability affect joint awareness after TKA.

Hypothesis: Patients undergoing TKA demonstrate changes in joint awareness and joint awareness is associated with pain, knee ROM, quadriceps strength, and functional ability.

Patients and methods: This prospective cohort study comprised 63 individuals undergoing TKA, evaluated at 1, 6, and 12 months postoperatively. Outcomes included joint awareness assessed using the Forgotten Joint Score (FJS), pain score, knee ROM, quadriceps strength, and functional ability.

Results: Fifty-eight individuals completed all postoperative assessments. All measures except for knee extension ROM improved from 1 to 6 months. However, there were no differences in any measures from 6 to 12 months. FJS was affected most greatly by pain at 1 month and by quadriceps strength at 6 and 12 months.

Discussion: Patients following TKA demonstrate improvements in joint awareness and function within 6 months after surgery, but reach a plateau from 6 to 12 months. Quadriceps strength could contribute to this plateau of joint awareness.

Level of evidence: Prospective cohort study, IV.

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1. Introduction

Total knee arthroplasty (TKA) is the most common surgical intervention for knee osteoarthritis (OA), offering pain relief, functional recovery, and an improved quality of life (QOL) [1,2]. The primary objectives of TKA are often pain alleviation, and improvement in knee range of motion (ROM) and functional ability. Traditional rating systems assessing the outcome after TKA frequently focus on “objective” surgeons’ ratings. However, patients’ concerns after TKA do not always agree with those of surgeons [3,4]. Therefore, there has been a growing trend towards patient-reported outcome (PRO) tools to provide a more patient-centered view on treatment outcomes [5–8].

The “Forgotten Joint Score (FJS)” is such a PRO tool, which was developed to evaluate the patient’s ability to forget the artificial joint and joint awareness in everyday life [9]. Forgetting the artificial joint can be regarded as the goal in joint arthroplasty, and results in the greatest possible patient satisfaction [9,10]. So far, no study has assessed the change in joint awareness after TKA. Understanding the actual change of joint awareness after TKA is essential to get a clear picture of the ability to forget the artificial joint. Therefore, our goal was to describe changes in joint awareness in the artificial joint after TKA.

The information regarding the factors affecting joint awareness is little, with some previous studies indicating that joint awareness is affected by sex [9], location (knee versus hip) [9], and types of knee arthroplasty (posterior stabilized total knee arthroplasty versus patellofemoral resurfacing arthroplasty) [10]. Postoperative pain, quadriceps strength, and functional ability are major concerns to surgeons; however, the associations between joint awareness and those outcomes remain unclear. Our secondary objective was to determine which factors among pain, knee ROM, quadriceps strength, and functional ability affect joint awareness after TKA.

We hypothesized that patients undergoing TKA demonstrate changes in joint awareness. Additionally, joint awareness is associated with pain, knee ROM, quadriceps strength, and functional ability.
2. Patients and methods

This prospective cohort study included individuals undergoing TKA, evaluated at 1, 6, and 12 months postoperatively by three physical therapists. The 12 months' follow-up time was selected because patients demonstrate most of the changes in strength and functional gains within 6 months, and plateau in strength and functional ability within 12 months [11–13]. This study was approved by the institutional review board and informed consent was obtained from all participants.

Sixty-three individuals with knee OA (all women, age: 71.7 ± 6.3 years) were recruited at a local orthopaedic hospital. The inclusion criteria were as follows: (1) age between 50 and 80 years; and (2) primary TKA for knee OA staged as grade 4 based on the Kellgren and Lawrence radiographic grading system [14]. The exclusion criteria were as follows:

- patients who were wheelchair-bound;
- presence of uncontrolled hypertension or diabetes;
- neurologic impairments;
- coexisting OA or other orthopaedic conditions in the contralateral hip or knee requiring surgery within 12 months.

A previous study showed a difference between sexes in outcomes after TKA [15]. Based on this previous research, it was expected that being of a particular sex could affect joint awareness after TKA. Therefore, we targeted only women, considering the prevalence of knee OA is higher in women than in men [16,17].

All 63 patients had a varus deformity. Three surgeons performed TKA by using a posterior stabilized knee prosthesis (Evolution PS [Microport Inc.], Vanguard PS [Zimmer Biomet Inc.], Persona PS [Zimmer Biomet Inc.], and Genesis II [Smith & Nephew Inc.]) via a medial parapatellar approach. After surgery, patients underwent performed standard 5-day inpatient and 12-week outpatient rehabilitation programs. These programs aimed at controlling pain and swelling, and improving knee ROM, muscle strength, and functional ability.

Joint awareness was measured using the FJS-12 [9] (Electronic appendix 1). The FJS-12 is a self-administered questionnaire used to assess the degree of patients’ awareness of their artificial joint using a five-grade Likert scale. The FJS-12 comprises of 12 questions regarding whether patients are aware of having undergone arthroplasty during activities of daily living (such as being in bed at night, climbing stairs, and taking a bath), and during relatively difficult movements such as housework, standing for long periods of time, and sports, irrespective of pain, ROM, or leg-length discrepancy. The scoring method of the FJS-12 is as follows:

- 0: never;
- 1: almost never;
- 2: seldom;
- 3: sometimes;
- 4: mostly.

The final score range is 0 (best) to 100 (worst). Low scores indicate good outcome, that is, increased “forgetting” of the artificial joint. A previous study has reported the reliability and the validity of the Japanese version of the FJS-12 [18].

Knee ROM was measured using a standard long-arm goniometer. The axis of the goniometer was aligned with the centre of the lateral epicondyle of the femur. The distal arm of the goniometer was aligned with the lateral malleolus and the proximal arm with the greater trochanter. Passive knee flexion and extension ROM were performed in the supine position.

Quadriceps strength was measured as the peak isometric knee extension torque (Nm/kg) using a hand-held dynamometer (μTas.

Fig. 1. Illustration of dynamometer placement used for the measurement of quadriceps strength.

F1: ANIMA, Chofu, Japan). Patients were seated with the hip flexed to 90° and the knee flexed to 75° [19]. The sensor of the dynamometer was placed 5 cm proximal to the lateral malleolus and a belt was used to restrain the dynamometer [20] (Fig. 1). The positioning of the dynamometer was recorded at the initial testing of each individual and a identical setup was used for each subsequent assessment. Patients were instructed to extend their knee maximally for approximately 3 seconds and two attempts were performed. The peak torque was estimated as the product of the force and the distance between the sensor of the dynamometer and knee joint. The trial with the highest volitional force production was normalized to body weight and used for analysis.

Functional ability was assessed using the Timed up and Go (TUG) test [21] that measures the time it takes a patient to rise from a no- arm chair (seat height 40 cm), walk 3 m, turn, and return to sitting in the same chair. Patients were instructed to walk as quickly as possible so long as they felt safe and comfortable. The average of two subsequent trials was used for analysis. Patients were allowed to use a cane if they felt unsafe or could not complete the test without a cane.

The pain score was derived from the category of symptoms in the Knee Society Score [22]; the intensity of pain with level walking. This score gave a pain score as an integer, ranging from 0 to 10, with 0 = no pain and 10 = maximal pain.

Only patients with complete data for all given time points were used for statistical analysis. The normality of the parameter distribution was verified with the Shapiro-Wilk test. First, the time course of FJS, pain, knee ROM of flexion and extension, quadriceps strength, and functional ability were described. Second, multiple linear regression using forward-backward stepwise entry was used to identify which factors of pain, knee ROM, quadriceps strength, and functional ability were affecting the FJS at each time point. For forward-backward selection, the entry level was set at 0.05 and the removal level was set at 0.10. All statistical testing was performed at 0.05 level of significance unless otherwise stated. SPSS software version 22.0 (IBM, Tokyo, Japan) was used for statistical analyses. An exploratory design was used for this study. An estimation of the required sample size was performed according to Harris’ formula [23]. Harris suggested that the number of participants should exceed the number of independent variables by at
least 50; therefore, it was determined that the required sample size should be at least 55 in this study. To allow for undetermined problems (i.e., missing postoperative tests), an additional 8 patients were included, thus making a total of 63 patients.

### 3. Results

Five patients who missed postoperative tests were excluded, leaving 58 individuals who were included in the analyses (Table 1). FJS improved from the 1-month (mean: 45.7 ± 15.9) to the 6-month assessment (mean: 27.4 ± 16.2); however, there was no difference in FJS between 6 and 12 months (12 months’ mean: 25.4 ± 16.2) (Table 2). We also found improvements in knee flexion ROM, quadriceps strength, TUG score, and pain score from the 1-month to the 6-month assessment (Table 2). Furthermore, there were no differences in these outcomes between 6 and 12 months. Knee extension ROM did not significantly differ from 1 to 12 months (Table 2).

At 1 month postoperatively, pain score (P < 0.001) and quadriceps strength (P < 0.001) were included in the final multivariate models (R² = 0.82) (Table 3). The standardized beta coefficient indicated that the pain score was the most influential variable in the FJS at 1 month postoperatively. At 6 and 12 months postoperatively, the final multivariate models included quadriceps strength (P < 0.001) and the TUG score (6 months: P = 0.006, 12 months: P = 0.04) (6 months: R² = 0.50, 12 months: R² = 0.54) (Tables 4 and 5). Quadriceps strength was the most influential variable in the FJS at 6 and 12 months judged by the standardized beta coefficient (6 months: −0.63; 12 months: −0.68).

### 4. Discussion

The goal of this study was to describe changes in joint awareness in the artificial joint after TKA. We hypothesized that patients undergoing TKA demonstrate changes in joint awareness. As we had expected, we found changes in joint awareness with time. Most of the change in joint awareness was observed within the first 6 months and patients reached a plateau of the level of joint awareness from 6 to 12 months. Although the change in physical function after TKA is fairly well known [11–13], this is the first study to investigate the change in joint awareness after TKA. Most of the changes in strength and functional ability are reported to occur within 6 months [11–13] and patients reach the plateau of the recovery within 12 months [12]. In this study, the changes in joint awareness followed a similar course to those in quadriceps strength and functional ability. This could be due to the association between joint awareness and those outcomes.

Our secondary objective was to determine which factors affect joint awareness after TKA. We hypothesized that joint awareness is associated with pain, knee ROM, quadriceps strength, and functional ability. Our results show that joint awareness was significantly affected by pain and quadriceps strength. Joint awareness was the most influenced by pain at 1 month and by quadriceps strength at 6 and 12 months. Pain and quadriceps weakness are considered the most important factors after TKA. Pain is usually the primary criterion of success or failure after TKA and quadriceps weakness is the primary impairment in individuals with TKA. Pain and quadriceps weakness are related to disability [19,24,25], patient satisfaction [26], and QOL [25,27,28]. Our results add to these findings by showing the effects of pain and quadriceps weakness on joint awareness after TKA.

Although pain was the most influential factor for joint awareness at 1 month, joint awareness at 6 and 12 months was affected most greatly by quadriceps strength. This shift in the factors affecting joint awareness could be due to the difference between pain and quadriceps weakness. Patients following TKA often experience severe pain early after surgery, and considerable pain reduction is obtained within 6 months [29–31]. On the other hand, at 6–12 months, quadriceps strength increases to the preoperative strength level, although still considerably weaker than healthy age-matched individuals [32,33]. Thus, quadriceps weakness becomes the primary postoperative impairment that persists long term after TKA. These differences in pain and quadriceps weakness could result in the shift in the factors affecting joint awareness. Additionally, patients demonstrated the greatest change of quadriceps strength within 6 months and no change in quadriceps strength from 6 to 12 months. Our results are in line with previous studies.

### Table 1

Characteristics of patients.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>71.7 ± 6.3</td>
<td>54–79</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>152.5 ± 9.0</td>
<td>138.8–172.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60.8 ± 8.8</td>
<td>43.0–79.0</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.2 ± 3.2</td>
<td>19.1–34.3</td>
</tr>
</tbody>
</table>

### Table 2

The time course of the Forgotten Joint Scores, range of motion, quadriceps strength, the Timed Up and Go test score, and pain score.

<table>
<thead>
<tr>
<th></th>
<th>1 month</th>
<th>6 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>CI</td>
<td>Range</td>
</tr>
<tr>
<td>Forgotten joint score</td>
<td>45.7 ± 15.9</td>
<td>41.2, 50.2</td>
<td>13–79</td>
</tr>
<tr>
<td>Range of motion</td>
<td>110.5 ± 13.3</td>
<td>106.7, 114.3</td>
<td>80–130</td>
</tr>
<tr>
<td>Extension (degree)</td>
<td>−2.8 ± 3.3</td>
<td>−3.7, −1.9</td>
<td>−10–0</td>
</tr>
<tr>
<td>Quadriceps strength (Nm/kg)</td>
<td>0.74 ± 0.34</td>
<td>0.64, 0.83</td>
<td>0.14–1.85</td>
</tr>
<tr>
<td>Timed up and Go test (seconds)</td>
<td>10.0 ± 2.4</td>
<td>9.3, 10.6</td>
<td>6.4–18.5</td>
</tr>
<tr>
<td>Pain score</td>
<td>3.4 ± 1.5</td>
<td>2.9, 3.8</td>
<td>0–9</td>
</tr>
</tbody>
</table>

SD: standard deviation; CI: 95% confidence interval.

### Table 3

Multiple linear regression analyses using stepwise entry for Forgotten Joint Scores at 1 month postoperatively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unstandardised coefficient</th>
<th>Standardised coefficient</th>
<th>Partial r</th>
<th>CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>39.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain score</td>
<td>6.11</td>
<td>0.57</td>
<td>0.70</td>
<td>5.92, 8.76</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Quadriceps strength</td>
<td>−19.46</td>
<td>−0.41</td>
<td>−0.57</td>
<td>−0.27, −0.11</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CI: 95% confidence interval.
[24–26], and this time course could contribute to the plateau of joint awareness from 6 to 12 months. These results may indicate that the improvement in quadriceps weakness reduces joint awareness.

Limitation of this study is the short follow-up period. But, 12 months follow-up is enough to examine which factors affect joint awareness after TKA, because most of the changes in pain, strength, and functions occur within 6 months [11–13]. However, previous studies reported joint awareness at 24 months [10] and 31.2 months [9] after TKA surgery, and future research should assess the long-term changes in joint awareness. Second, this study lacked a measurement of psychological characteristics. Psychological characteristics could also affect joint awareness because the FJS includes psychometric factors [9]. Future study should examine the influence of psychological characteristics on joint awareness.

In conclusion, the greatest change in joint awareness occurs within 6 months postoperatively, and patients reach a plateau of joint awareness from 6 to 12 months. Joint awareness is significantly affected by pain at 1 month postoperatively and by quadriceps strength at 6 and 12 months postoperatively. Targeted improvements in these factors may reduce joint awareness in the artificial joint after TKA.

Disclosure of interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi: 10.1016/j.otsr.2016.02.007.

References