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Original article

Diabetes is a Risk Factor for Restricted Range of Motion and Poor Clinical Outcome After Total Knee Arthroplasty

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ABSTRACT

Background: We investigated the effects of diabetes mellitus on knee range of motion, muscle strength, and functional outcome after total knee arthroplasty.
Methods: A total of 20 patients with type 2 diabetes and 20 patients without diabetes matched for age, body mass index, knee range of motion, and muscle strength at baseline participated in this study. We examined knee range of motion and muscle strength and assessed functional activities using the new Knee Society Score questionnaire for each patient 1 month preoperatively and at 6 and 12 months postoperatively.
Results: Patients with diabetes had significantly lower knee flexion and smaller improvements in the new Knee Society Score than patients without diabetes.
Conclusion: Our results suggest that clinicians should treat and monitor patients with diabetes closely to prevent restricted knee range of motion and poorer functional recovery after total knee arthroplasty.

Knee osteoarthritis (OA) is the most common joint disease [1] and is characterized by joint instability, muscle weakness, joint deformity, pain, and stiffness [2-6]. Total knee arthroplasty (TKA) is the most common surgical intervention for end-stage knee OA and is a cost-effective intervention for reducing pain, improving function, and enhancing the quality of life in patients with OA. Because the number of TKA operations is continuously increasing [7], it is important to clarify the factors affecting clinical outcomes after TKA. Many researchers have reported that patient characteristics, surgical procedure, and postoperative factors influence the outcome and prognosis of TKA [8-10].

Diabetes mellitus (DM) is a common chronic health condition worldwide. It is predicted that the global prevalence of this disease will increase from 6.4% in 2010 to 7.7% by 2030 [11]. It has been reported that patients with DM have more perioperative complications after TKA compared with patients without DM [12,13]. In addition, DM has been to known to adversely affect the musculoskeletal system by delaying collagen synthesis and impairing wound healing [14,15]. These factors would be expected to interfere with aggressive rehabilitation after TKA, which may lead to poorer clinical outcomes including a reduction in range of motion (ROM), muscle strength, and ability to perform routine activities. Robertson et al [16] demonstrated that patients with DM showed less improvement in maximal flexion and Knee Society scores (KSSs) compared with those without DM at 1, 5, and 10 years after TKA. However, baseline characteristics of the study patients were not well matched, and details of the effects of DM on clinical outcome in the short term after TKA were not clarified.

The purpose of this study was to determine the influence of DM on clinical outcome after TKA. We hypothesized that patients who have DM would have more restricted ROM, weaker muscle strength, and worse functional outcomes.

Materials and Methods

Study Design and Patients

This was a retrospective cohort study. We reviewed the clinical records of patients admitted to our hospital between April 2013 and

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March 2014 and found 186 patients who underwent primary TKA and were assessed both clinically and radiographically at 1 month preoperatively and at 6 and 12 months postoperatively. From these, 101 patients were selected for the study based on the following criteria. Patients were included if they received a primary TKA for knee OA assessed as grade 3 or 4 on the Kellgren–Lawrence's radiographic grading system [17]. Exclusion criteria were (1) age ≥80 years, (2) history of musculoskeletal surgery, (3) neurologic impairment, and (4) having undergone another operation during the follow-up period including TKA of the opposite leg. The presence of type 2 DM was defined as documentation of a glycosylated hemoglobin (HbA1c) ≥6.5% [18] in the clinical records. Of those 101 patients, 20 (10 men and 10 women) were identified as having a preoperative diagnosis of DM (DM group) and 81 (10 men and 71 women) were not diabetic (control group). After using propensity score matching for the female patients without DM, the 2 groups were well matched for baseline characteristics, such as age, body mass index, knee ROM, and quadriceps strength in the involved limb. We estimated the scores of each female patient in the DM group using a multivariable logistic regression model. We were able to match 10 pairs of female patients in both groups who had similar propensity scores.

Written informed consent was obtained from all study participants, and the study was approved by the Ethics Committee at our institution.

Rehabilitation Protocol

Patients in both groups underwent the same rehabilitation program, which consisted of a standard 5-day inpatient and 12-week outpatient rehabilitation program. All patients were treated twice daily by physical therapists during hospitalization. Ambulation exercises using suitable walking aids were started on postoperative day 1 with weight bearing as tolerated. Inpatient rehabilitation consisted of passive knee ROM exercises; patellofemoral joint mobilization as needed; incision mobility; lower extremity flexibility exercises for the quadriceps, calves, and hamstrings; icing; gait training; and functional training for transfers and stair climbing. After discharge from the hospital, patients were treated in outpatient physical therapy once a week. In addition, all patients were given a standard home exercise program to be performed twice daily. The home exercise program included ROM and strengthening exercises for the quadriceps, hamstrings, hip abductors, and hip extensors in weight-bearing and nonweight-bearing conditions. Rehabilitation intensity was lowered in case of suspicion of poor wound healing to prevent further complications, such as infection.

Physical Function

We measured passive knee flexion and extension ROM with the patients in the supine position. Knee ROM was measured using a standard goniometer with the axis placed over the lateral epicondyle of the femur, the proximal arm aligned with the greater trochanter of the femur, and the distal arm aligned with the lateral malleolus of the ankle.

We evaluated quadriceps strength by measuring the peak isometric knee extension torque (Nm/kg) using a handheld dynamometer (μTas F1; Anima, Chofu, Japan). Participants were seated with hips flexed at 90° and the knee flexed at 75°, and a belt was used to restrain the dynamometer [19]. Peak torque was estimated as the product of the force being exerted and the distance between the attachment of the dynamometer and the center of rotation of the knee joint. Maximal contraction was attempted twice, and the trial that produced the highest volitional force was normalized to body weight and used for analysis.

Functional Outcomes

The new KSS questionnaire [20] was used to assess functional outcome. The new KSS consists of 4 categories: symptoms (3 items, 25 points), patient satisfaction (5 items, 40 points), patient expectations (3 items, 15 points), and functional activities, which is divided into walking and standing (5 items, 30 points), standard activities (6 items, 30 points), advanced activities (5 items, 25 points), and discretionary activities (3 items, 15 points). Higher scores represent less pain and better level of patient satisfaction, expectations, and physical functioning. The new KSS is a validated and reliable instrument for use before and after TKA [21].

Statistical Analysis

With a significance level of 0.05, a power of 80%, and a medium effect size ($\eta^2 = 0.06$), the required sample size for each group was estimated to be 22 patients [22].

Baseline characteristics of the DM and control groups were compared. The Kolmogorov–Smirnov test was used to determine the normality of distribution. Differences between groups were analyzed using student *t* test for continuous variables with a normal distribution and the Mann–Whitney *U* test for non-normally distributed variables.

The effect of DM on outcome measurements was examined using repeated measures analysis of variance (ANOVA). If 2-way repeated ANOVA showed significant interactions, a Bonferroni post hoc test was used to identify the mean difference.

A *P* value <.05 was considered statistically significant. All statistical analyses were performed using SPSS for Windows, version 21.0 (IBM, Tokyo, Japan).

Results

Baseline Characteristics

Table 1 summarizes the baseline characteristics of the groups. No significant differences between the groups were observed for any of the characteristics examined, including age, weight, and height. There were also no significant differences in knee ROM, quadriceps strength, or new KSS.

Time Course for Both Groups

There were no patients who required reoperation due to complication during the follow-up period. Although there were no wound-healing complications in the control group, 2 patients in the DM group had wound-healing complications, and the intensity of the rehabilitation protocol for these patients was altered accordingly.

Effect of DM on Physical Function

The outcome measure results at 6 months and 1 year after TKA with ANOVA are presented in Table 2.

There was a statistically significant interaction between the effects of time and group in knee flexion in the involved leg (F[1, 38] = 3.880, interaction: $P = .045$, $\eta^2 = 0.093$). In patients without DM, the preoperative knee flexion in the involved leg was not significantly different than that at 6 and 12 months postoperatively. On the other hand, in patients with DM, knee flexion in the involved leg was significantly reduced at 6 months ($P = .006$) and at 12 months ($P = .011$) after TKA compared with that before the operation. In addition, knee flexion in patients without DM