Effect of self-calf massage on the prevention of deep vein thrombosis after total knee arthroplasty: A randomized clinical trial

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ABSTRACT. Objective: Deep vein thrombosis (DVT) is a severe complication after total knee arthroplasty (TKA). Performing self-calf massage may decrease the incidence of DVT. The purpose of this study was to investigate whether self-calf massage is effective for preventing DVT after TKA. Method: In all, 165 patients participated in the present study. Patients were randomized to one of two groups: the self-calf massage group or the control group. In the control group, patients started regular physical therapy. In the self-calf massage group, in addition to regular physical therapy, patients were instructed to massage their calf muscles 30 times from the distal to proximal side. This procedure was repeated three times and was completed in 2 mins during the 2 days following TKA. All patients were evaluated for DVT on postoperative day 3 using lower limb vein ultrasonography. Results: The incidence of DVT was significantly lower in the self-calf massage group than in the control group. Self-calf massage was associated with a lower incidence of DVT, whereas age and female sex were risk factors for DVT. Conclusion: This study showed that the self-calf massage may be beneficial for the prevention of DVT after TKA.

Key words: total knee arthroplasty, deep vein thrombosis, self-calf massage

Total knee arthroplasty (TKA) is a major lower limb surgery and deep vein thrombosis (DVT) is one of the most severe complications of TKA1-3). The rate of DVT after TKA ranges from 7-57% in Japan4-8). DVT may cause pulmonary embolism and can result in death in severe cases. The increased incidence of TKA in an aging population makes DVT a particularly worrying concern. Therefore, it is necessary to prevent DVT after TKA.

Several non-pharmacologic therapies are available for DVT prevention. Previous studies recommended actively moving the ankle joint, wearing graduated compression stockings, and intermittent pneumatic compression9-11). In addition, Imai et al. reported that passive calf massage and ankle motion are effective for DVT prevention after total hip arthroplasty (THA)12). Performing a passive manual calf massage and ankle movement immediately after surgery decreased the incidence of DVT from 6.5% to 0.8%12), and these effects can be expected for patients after TKA. However, the clinical application of this intervention just after surgery may be difficult because of physical deconditioning and the influence of anesthesia. In the present study, we investigated the benefits of self-administered calf massage (self-calf massage) starting a day after TKA. Self-calf massage is clinically useful, safe, and low-cost.

The purpose of this study was to investigate the effect of the self-calf massage for preventing DVT after TKA. We hypothesized that performing self-calf massage will be effective for preventing DVT and will decrease the incidence of DVT after TKA.
Method

Participants

The ethics committee of Anshin hospital approved the present study (approval protocol number: 45; date of approval: October 22nd, 2015). All patients provided written informed consent before participating in the study, which was performed in accordance with the Declaration of Helsinki. The trial was registered in the UMIN Clinical Trials Registry, number UMIN000031327. This parallel trial was conducted at a single center.

A total of 173 patients who underwent primary unilateral TKA at an orthopedic clinic from January to June 2016 participated in the present study. The inclusion criteria were as follows: (i) diagnosis of medial osteoarthritis and (ii) no medical history of DVT. The exclusion criteria included: (i) long-term use of anticoagulation or antiplatelet agents for pre-existing cardiac or cerebrovascular disease; (ii) coagulation disorder (including antiphospholipid syndrome); and (iii) inability to walk because of postoperative pain on the day following TKA. Three patients were excluded for not meeting the inclusion criteria. Patients were randomized to one of two groups: a self-calf massage group or control group according to a computerized random sequence generator. Of the 170 patients, four were unable to walk on the day after TKA and one was unable to perform self-calf massage. Therefore, 165 patients were enrolled in the present study. Of these, 81 participants (49%) were classified into the self-calf massage group and 84 participants (51%) were classified into the control group (Figure 1).

Procedure

Before surgery, all patients were placed in a supine position and a tourniquet was applied. TKA were performed by five expert surgeons through a medial para-patellar approach. Patients had a conventional intermittent pneumatic compression device applied to the soles of both feet from the induction of general anesthesia until the morning of the day following the TKA. Graduated compression stockings were worn on both legs for 1 month, postoperatively. The patients did not receive anticoagulant therapy. Patients in both groups started regular physical therapy on the day following TKA and followed a standard protocol of ambulation exercises and activities of daily living exercises. The rehabilitation program included exercises such as the ankle pump, hip adduction, quadriceps setting, and active-assisted range of motion exercises to improve knee function. Ambulation exercises were started using a walker. After achieving independent ambulation with the walker, ambulation exercises using a cane were introduced. The mobility-related goal at discharge was to achieve safe ambulation using a cane.

Intervention (Figure 2)

The self-calf massage group performed self-calf massage for the 2 days following the TKA. In the starting position, the patient was placed in the long-sitting position on the bed while the hip and knee joints were both at approximately 30° of flexion. Before starting the postoperative rehabilitation at the day following the TKA, we demonstrated to the patients how to massage their calf muscles by performing it on ourselves. Self-calf massage was performed...
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30 times at an intensity that could be tolerated by the patient depending on the level of pain experienced. After the self-calf massage, the leg was lowered onto the bed for 10 s to allow the return of venous blood flow. This procedure was repeated three times and was completed in 2 mins for 2 days following TKA. The details of this procedure have been outlined in a previous study. Five trained examiners, who was a physical therapist (T.O., O.W., T.S., S.N., and K. M.), confirmed whether the patients performed the procedure correctly.

**Evaluation of DVT**

D-dimer levels, which are widely used in the screening of DVT as an index of fibrin resolution, were measured 1 month preoperatively and on postoperative day 3 in order to identify the presence of DVT after TKA. We measured the D-dimer level using the latex cohesion method. Patients with high D-dimer levels (>5.0) preoperatively underwent ultrasonography to confirm the presence of DVT before TKA, as a definitive diagnosis via imaging is required. All patients were evaluated for DVT on postoperative day 4 using lower limb vein ultrasonography. We used a 13-MHz linear model probe and a 5-MHz convex type probe for the ultrasonography (Avius, Hitachi Corporation, Japan). A clinical technologist performed the lower limb vein ultrasonography for all patients. The patients were examined in the supine position, and we observed a breathing-related change in venous blood flow with pulse Doppler in the entire femoral vein. Next, we scanned from the common femoral vein to the superficial femoral vein and popliteal vein with a crossing image, compressed a vein with the probe (pressure method), and observed whether the vein got compressed under pressure. Then, the patient was moved to the sitting position, and we scanned each vein from a crossing image of the posterior tibia and fibula and observed them using the pressure method. We also used color Doppler imaging and observed a change in the venous return flow by pressing the tip manually from an observation point. For the muscle branch in the thigh, we carefully observed the presence of the vein, which enlarged in B mode, by moving parallel translation in the soleus muscle and evaluated it using the pressure and color Doppler imaging. A diagnosis of DVT was confirmed in B mode by the non-compression of the vein lumen with the pressure method and by signal stream loss or non-recognition using the milking method. The examiner was blinded to the allocation. The blinded randomization list was dispatched to the examiner.

**Clinical characteristics and preoperative physical function**

We collected sociodemographic data such as age, sex, weight, height, body mass index (BMI), operation time, tourniquet time, and frequency of outpatient rehabilitation from medical records. Knee ROM was measured using a standard 2-arm plastic 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. Gait speed was measured twice for each participant. All participants were instructed to walk at their preferred speed along a 16-m smooth, horizontal walkway. A 10-m section of the walkway was marked off by two lines positioned 3 m from each end to allow space and time for acceleration and deceleration. The time taken to complete the middle 10-m distance was recorded to the nearest hundredth of a second using a stopwatch. The timed-up-and-go (TUG) test was used to evaluate the time it takes to rise from a chair, walk 3 meters, turn around, and return to a seated position. Participants were instructed to walk as fast as possible, and completed two trials each; the fastest time was used for analysis.

**Statistical analysis**

Data are expressed as means ± standard deviation (SD). A chi-square test or Fisher’s exact test was used to compare qualitative data, such as sex and the tourniquet time. Fisher’s exact test was used to compare the incidence of DVT between both groups. Unpaired Student’s t-tests were used to analyze quantitative data, such as age and BMI. Multiple logistic regression analyses were used to determine which of the following factors contributed to the incidence of DVT: age, sex, BMI, tourniquet time, and self-calf massage. This was the method of statistical analysis was utilized by Imai et al.

All analyses were performed using SPSS for Windows 21.0.0 version (IBM, Tokyo, Japan), at a two-tailed alpha level of 0.05. The statistical significance for all analyses was set at \( p < 0.05 \).

**Results**

**Characteristics (Table 1)**

The characteristics of both groups are summarized in
Table 1. Clinical characteristics and preoperative physical function

| Variables                              | All subjects (n=165) | Self-calf massage group (n=81) | Control group (n=84) | p-value |
|----------------------------------------|----------------------|--------------------------------|----------------------|---------|
| Age, yrs                               | 73.0 ± 7.9           | 72.5 ± 8.7                     | 73.4 ± 7.1           | 0.47    |
| Female, n, %                           | 136, 82.4            | 65, 80.2                       | 71, 84.5             | 0.47    |
| Height, cm                             | 153.4 ± 7.4          | 153.8 ± 7.8                    | 153.1 ± 7.1          | 0.57    |
| Weight, kg                             | 62.3 ± 11.3          | 62.7 ± 12.9                    | 62.1 ± 9.7           | 0.75    |
| Body mass index, kg/m²                 | 26.4 ± 4.0           | 26.4 ± 4.3                     | 26.5 ± 3.7           | 0.82    |
| Operation time, min                    | 82.2 ± 17.4          | 81.2 ± 17.4                    | 83.2 ± 17.5          | 0.47    |
| Tourniquet time, min                   | 71.5 ± 13.4          | 71.1 ± 11.7                    | 71.8 ± 13.3          | 0.64    |
| Length of stay, days                   | 6.0 ± 0.9            | 6.1 ± 1.1                      | 6.0 ± 0.6            | 0.30    |
| Preoperative D-dimmer                  | 1.1 ± 0.9            | 1.2 ± 1.1                      | 1.1 ± 0.8            | 0.67    |
| Preoperative knee ROM flexion, °       | 123.3 ± 14.3         | 123.4 ± 13.5                   | 123.2 ± 15.8         | 0.94    |
| Preoperative knee ROM extension, °     | -8.4 ± 6.4           | -8.7 ± 6.5                     | -8.2 ± 6.4           | 0.55    |
| Gait speed, m/s                        | 0.93 ± 0.26          | 0.89 ± 0.27                    | 0.95 ± 0.25          | 0.14    |
| Timed up & go test, s                  | 10.5 ± 3.2           | 10.6 ± 3.3                     | 10.4 ± 3.0           | 0.72    |

Data are expressed as means ± standard deviations. ROM: range of motion, significant level: p < 0.05

Table 2. Incidence of DVT in the self-calf massage and control groups

| Variables                              | All subjects (n=165) | Self-calf massage group (n=81) | Control group (n=84) | p-value |
|----------------------------------------|----------------------|--------------------------------|----------------------|---------|
| The incidence of DVT, n (%)            | 48 (29.1)            | 17 (21.0)                      | 31 (36.9)            | < 0.001 |
| Postoperative D-dimmer                 | 5.0 ± 8.7            | 4.2 ± 2.2                      | 5.8 ± 12.0           | 0.25    |

Data are expressed as means ± standard deviations. DVT: deep vein thrombosis, significant level: p < 0.05

Table 3. Factors contributing to the incidence of deep vein thrombosis

| Independent Variables | odds ratio | 95% confidence | p-value |
|-----------------------|------------|----------------|---------|
| Age                   | 1.10       | 1.04-1.16      | < 0.01  |
| Female sex            | 8.80       | 1.90-40.70     | < 0.01  |
| Self-calf massage     | 0.43       | 0.20-0.91      | 0.03    |

significant level: p < 0.05

Table 1. There were no significant differences between the groups in clinical characteristics, preoperative physical function, and operative variables, such as operative time and tourniquet time.

Incidence of DVT

The incidence of DVT in both groups is shown in Table 2. The incidence of DVT was significantly lower in the self-calf massage group (17/81, 21.0%) than in the control group (31/84, 36.9%) (p < 0.001). During the follow-up, no patient had a symptomatic pulmonary embolism, major or minor bleeding, and or dislocation or infection at the surgical site after the TKA.

Factors affecting the incidence of DVT

The results of the multilinear regression analysis are shown in Table 3. The incidence of DVT was associated with age (odds ratio [OR] = 1.1, 95% confidence interval [CI]: 1.04 - 1.16, p = 0.001), female sex (OR = 8.8, 95% CI: 1.90 - 40.70, p = 0.005), and self-calf massage (OR = 0.4, 95% CI: 0.20 - 0.91, p = 0.03).

Discussion

This study aimed to examine the effectiveness of self-calf massage for DVT prevention after TKA, and we hypothesized that self-calf massage might decrease the incidence of DVT. The primary outcome was the incidence of DVT on postoperative day 3. Our study showed that the incidence of DVT was significantly lower in the self-calf massage group than in the control group. In addition, based on the results of multilinear regression analysis, self-calf massage was an important factor affecting the incidence of DVT.

These results supported our hypothesis and indicated that self-calf massage may be beneficial for the prevention of DVT after TKA. To our knowledge, our study is the first to show the effect of self-calf massage for decreasing the incidence of DVT after TKA. Prevention of phlebostasis in the lower limbs is important for preventing DVT incidence after TKA. Roberts and Sabri et al. reported that compressing the veins in the calf increased venous blood flow and
venous blood flow velocity\(^{(10)}\). Increasing venous blood flow and venous blood flow velocity leads to decreased venous stasis and prevents refluxing, which is a precursor of DVT\(^{(17)}\). Therefore, it was considered that performing self-calf massage leads to the prevention of DVT after TKA.

The rate of DVT was 21.0% in the self-calf massage group and 36.9% in the control group. Imai and Ito et al. reported that passive calf massage and ankle motion decreased the DVT incidence from 6.5% to 0.8% after THA\(^{(12)}\). We suggest three reasons why there was a lower rate of decline in DVT incidence in our study compared to the previous study. First, the mean age of participants in the present study was higher than that in the previous study (73.0 vs 62.9 years). Age is an important contributory factor to the incidence of DVT\(^{(18)}\). Second, tourniquets were applied to the TKA patients in the present study but not to the THA patients in the previous study, and the use of a tourniquet is an important risk factor for DVT\(^{(19)}\). Finally, the time of the intervention after the operation seemed to play a role in the differences in DVT decline. In the previous study, the calf massage was performed immediately after surgery, whereas in the present study the calf massage was performed the day after surgery. A previous study reported that the rate of DVT was 39% the following day after TKA\(^{(20)}\). Therefore, performing self-calf massage on the same day after TKA may yield better results than performing it on the day after TKA; however, further studies are needed to verify this hypothesis.

Our study had several limitations. First, this study was a single-center, short-term study with an endpoint of 3 days. However, all patients were followed as inpatients for 6 days in an outpatient clinic. None of the patients in whom DVT was detected using lower limb vein ultrasonography on postoperative day 7 had symptomatic pulmonary embolism, including calf pain and edema related to DVT. Second, we did not use contrast-enhanced computed tomography and magnetic resonance imaging for the diagnosis of DVT. However, ultrasonography is non-invasive, safe, and repeatable. Therefore, a reduction in detected DVT by ultrasonography can be assumed to be a reasonable goal for postoperative thromboprophylaxis and is the diagnostic standard in most hospitals. Finally, we could not calculate the sample size. It is possible that the \(\beta\) error due to a small sample size affected the results.

**Conclusion**

The present study showed that the self-calf massage was effective for the prevention of DVT after TKA. Moreover, the self-calf massage is safe and noninvasive.

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