J Musculoskelet Neuronal Interact 2023; 23(2):223-227

Journal of Musculoskeletal and Neuronal Interactions

Original Article

# The acute effect of roller massager on knee joint range of motion and muscle pain in older adults with total knee arthroplasty

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**Abstract**

**Objectives**: Older adults with total knee arthroplasty (TKA) have a limited range of knee joint motion due to pain and stiffness. A roller massager (RM) has recently been suggested to decrease pain and increase joint range of motion (ROM). Therefore, this study aimed to investigate the acute effect of RM intervention on pain and knee joint ROM in older adults with TKA in the second postoperative week. **Methods**: The participants were 23 patients (76.3±5.4 years) who had undergone TKA for knee OA. The degree of pain during the ROM measurements was measured using the visual analog scale before and immediately after the RM intervention. The RM intervention was performed on the thigh's lateral, central, and medial parts for three sets of 60 s using an RM. **Results**: RM intervention could significantly increase knee flexion ROM ($p<0.01$, $d=0.41$, Δchange: 4.1±3.2°) and decrease pain during the knee ROM measurements ($p<0.01$, $d=-0.53$, Δchange: -11.9±21.0). **Conclusions**: The three sets of 60-s RM intervention significantly increased knee flexion ROM and reduced pain in older adults with TKA in the second postoperative week. These results show that RM intervention is an effective tool for treating stiffness and pain after TKA.

**Keywords:** Flexion, Extension, Osteoarthritis, Range of Motion, Self-Massage

## Introduction

Osteoarthritis (OA) is the most common musculoskeletal disorder, affecting 10% of men and 18% of women over 60 all over the world[1]. The pain and stiffness caused by hip and knee OA are a physical, psychological, and social burden for patients, and surgical intervention is often required[2]. Total knee arthroplasty (TKA) is one of the most effective treatments for knee OA, and is effective in treating end-stage symptoms of knee OA, reducing knee pain, and improving knee function and quality of life (QOL)[3]. On the other hand, joint stiffness after TKA and stiffness of the entire knee due to reduced flexibility of muscles and tendons can lead to knee joint range of motion (ROM), which can impair QOL. Rodríguez-Merchán et al. reported that factors contributing to stiffness after TKA include the patient's motivation for rehabilitation and inadequate pain management[4]. In previous studies, the incidence of stiffness has been reported to be 8–12%[5-7]. In clinical practice, we have experienced cases in which patients with stiffness continue to have limited knee joint ROM, mainly due to pain and inability to practice knee joint ROM actively. Stiffness can also impair knee joint ROM and affect the activities of daily living, such as walking and climbing stairs. Laubenthal et al. reported that an average

The authors have no conflict of interest.

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*Edited by: G. Lyritis*
*Accepted 27 January 2023*

knee flexion angle of 83° is required to climb stairs, and an average knee flexion angle of 106° is required to tie shoelaces in the sitting position. Thus, limited ROM of the knee joint can impair these activities of daily living and lead to a narrowing of the range of daily living[8]. Esler et al. also investigated the effects of continued physical therapy on 21 patients with a knee joint flexion ROM of 80° or less at 6 weeks after TKA surgery. The results showed no significant changes in knee joint flexion ROM at 6 months and 1 year postoperatively, and no significant differences were found when comparing 1 year and 2 years postoperatively[9]. Thus, when knee joint ROM is limited due to pain or stiffness, physical therapy is difficult to manage, and invasive treatment might be necessary. Therefore, it is important to reduce pain and avoid the need for invasive treatment. Consequently, it is essential to establish a practical approach to treating pain and stiffness in patients with TKA.

Recently, roller massager (RM) has been attracting attention as a way to alleviate pain and improve ROM as an alternative to stretching intervention in sports settings. Recent meta-analyses have shown that other self-massage techniques, such as foam rolling (FR), appear to be equally effective in increasing ROM compared to stretching acutely[10] and in the long term[11]. In addition, previous studies have reported an increase in pain pressure threshold and ROM immediately after an FR intervention[10,12-15]. For example, Nakamura et al. (2020) showed that FR could decrease pain and improve ROM in healthy subjects with post-exercise delayed onset muscle soreness[16]. Previous studies have also reported that FR intervention can effectively improve ROM in patients with hip OA[17] and fibromyalgia[18]. In patients with hip OA, the VAS for hip pain improved significantly in the FR and non-FR groups, but this improvement was more significant in the FR group than in the non-FR group[17]. Regarding the FR effect on fibromyalgia, the meta-analysis found a large significant effect of myofascial release techniques, including FR and manual therapy, on pain after the treatment, a moderately significant effect at 6 months after treatment, and a moderate at 6 months post-treatment[18].

Based on these results, FR intervention, which can be performed without causing joint movement, might be effective in treating pain and decreased knee joint ROM in patients with TKA. Karaborklu et al. (2021) compared the effect of the combination of exercise and manual therapy and exercise alone in TKA patients[19]. They reported that the exercise program combined with manual therapy could improve pain, function, and patient satisfaction more than the exercise program alone for postoperative TKA patients[19]. Also, a recent review[20] showed that manual therapy techniques could contribute positively to the treatment of patients with knee OA by reducing pain and increasing functionality. In contrast to the manual therapy used in the previous studies, RM intervention could be performed by the patients themselves. Therefore, if RM intervention is effective in improving pain and ROM in TKA patients, we believe that it can be applied as a new form of self-care in rehabilitation settings. Therefore, this study aimed to investigate the acute effect of RM intervention on pain and knee joint ROM in TKA patients in the second postoperative week.

## Materials and Methods

*Participants*

The participants were 23 knee OA patients who had been admitted to Takeda General Hospital since October 2021 and underwent TKA. The mean age was 76.3±5.4 years (range: 69–83 years), and 91.3% (n=21) were female. Ten patients of the 23 patients had surgery on the right knee joint. All patients underwent right knee arthroplasty using the medial parapatellar approach. Exclusion criteria were those who could not give consent for the study and those who had rheumatoid arthritis in their current medical history. The sample size required for paired t-test (effect size=0.8 (large), alpha error=0.05, power=0.95) based on our previous study's VAS results[16] using G*power 3.1 software (Heinrich Heine University, Düsseldorf, Germany) was 23 participants. An ethical review was conducted after obtaining approval from the Ethical Review Committee of Takeda General Hospital (approval number: 292).

*Physical therapy intervention*

The physical therapy intervention conducted under the physician's direction included wheelchair use, joint ROM exercises, strength training, and walking exercises using a walking aid, according to the pain and general condition from the day after surgery.

*Roller massager (RM) exercise*

In the TKA protocol used at Takeda General Hospital, wound extraction is performed in the second postoperative week. Before the intervention, a physical therapist confirmed that there were no problems with the surgical wound. In the second postoperative week, an RM intervention with a stick type (TheraBand, Akron, OH, United States) was performed. A physical therapist performed RM intervention with at least one year of experience. The use of RM was supervised and standardized by a physical therapist with at least 10 years of experience. The intensity of RM was set to a pain-free range. RM intervention was performed for 60 s each, in the order of anterior, medial, and lateral thigh, starting at a site 5 cm above the nearest edge of the surgical wound and moving toward the hip joint, following a previous study[21]. We defined one cycle of RM intervention as one distal rolling plus one subsequent proximal rolling movement, whereas the frequency was defined as 30 cycles per 60 s (for a total of 90 cycles in three sets). The participants were asked to perform the RM intervention as much as was tolerable.

*Knee flexion and extension ROM measurement*

Both before and after the RM intervention, a physical therapist used a goniometer to measure the knee joint flexion and extension ROM in increments of 5°. Each participant was instructed to lie in a supine position and relax, and the knee joint was flexed or extended to the maximum pain the subject could tolerate[16].

*Pain measurement*

The degree of pain was measured using the visual analog scale (VAS) during the knee joint ROM measurement. Using a VAS that had a continuous 100-mm line with "not sore at all" on one side (0 mm) and "very, very sore" on the other side (100 mm), the magnitude of pain around the knee joint and knee extensor muscle was assessed during the knee joint ROM measurement.

*Reliability of the outcome measurements*

We investigated the reliability of the knee flexion and extension ROM and VAS during the ROM measurement with 15 patients (age 78.3±3.5 years). We investigated the knee flexion and extension ROM and VAS during the ROM measurement before and after the 180-s rest in the supine position. The test-retest reliability of the measurements was determined by the intraclass correlation coefficient (ICC) and standard error of measurement (SEM). The ICCs of the knee flexion and extension ROM and VAS were 0.92, 1.00, and 0.997, respectively, and the SEM of the knee flexion and extension ROM and VAS was 3.01, 0.0, and 1.37, respectively.

*Statistical analysis*

The data distribution was assessed using a Shapiro-Wilk test. The knee flexion ROM and pain followed a normal distribution. However, the knee extension ROM did not follow a normal distribution. Thus, we investigated the acute effect of the RM intervention on knee flexion ROM and pain using a paired t-test. In addition, knee extension joint ROM was compared using the Wilcoxon signed-rank test. We also calculated the effect size (Cohen's d) as the difference in the mean value divided by the pooled standard deviation (SD) between pre- and post-intervention in each group. A Cohen's d value of 0.00–0.19 was considered as trivial, 0.20–0.49 as small, 0.50–0.79 as moderate, and ≥0.80 as large[22,23]. The significance level was set at less than 5%. SPSS Statistics 28 was used as the statistical software.

## Results

The knee flexion ROM was 97.8±10.2° before the RM intervention and 102.0±10.3° immediately after the RM intervention, showing a significant increase in knee flexion ROM ($p<0.01$, $d=0.412$, Δchange: 4.1±3.2°). On the other hand, the knee extension ROM was -5.4±4.2° before the RM intervention and -5.2±3.8° immediately after the RM intervention, showing no significant difference ($p=0.32$, $d=0.055$, Δchange: 0.2±1.0°). In addition, pain during the ROM measurement was 44.8±23.2 mm before the RM intervention and 33.0±22.6 mm immediately after the RM intervention, indicating a significant decrease in pain ($p<0.01$, $d=-0.53$, Δchange: -11.9±21.0).

## Discussion

In this study, we investigated the acute effect of RM intervention on knee flexion and extension ROM and pain in older adults with TKA in the second postoperative week. The results showed that three 60-s sets (180 s in total) of RM intervention significantly increased knee flexion ROM and reduced pain. These results indicate that RM intervention is an effective tool for treating stiffness and pain after TKA. To the best of our knowledge, this is the first study to investigate the acute effect of RM intervention on older adults with TKA.

Previous studies have pointed out that a lot of patients suffer from stiffness after TKA[5-7]. Donaldson et al. also pointed out that stiffness after TKA can impair knee ROM[24]. Therefore, it is necessary to decrease the stiffness resulting from reduced flexibility of the muscles and tendons after TKA to prevent knee ROM limitation. The results of this study showed that a 180-s RM intervention (three sets of 60 s) on the thigh, i.e., mainly quadriceps muscle, significantly increased knee flexion ROM ($p<0.01$, $d=0.412$). In a previous study, the Minimal clinically important difference in knee flexion ROM from post-TKA to the 12$^{th}$ postoperative week was reported to be 9.6°. In the present study, an improvement of 4.1±3.2° was observed immediately after a single RM intervention. Also, the change in knee flexion ROM was larger than the SEM value. Thus, we believe that The result are clinically useful. Many previous studies have investigated the acute effects of FR intervention in healthy young subjects, and have reported that FR can increase ROM significantly and is as effective as a stretching intervention[10,15]. Nakamura et al. also showed that an FR intervention for 90 s or longer is necessary to increase ROM[25]. In addition, FR intervention can also increase ROM in muscles with delayed onset muscle soreness[16]. Although the mechanism of the increased ROM observed in the present study is unknown, previous studies have suggested that increased ROM after an FR intervention could be associated with an increase in pain tolerance (i.e., stretch tolerance)[26,27]. Therefore, it is possible that three 60-s sets (180 s in total) of RM intervention in older adults with TKA in the second postoperative week can increase pain tolerance, resulting in the increase in knee flexion ROM seen in this study.

In addition, the three 60-s sets (180 s in total) of RM intervention significantly reduced VAS during the ROM measurement ($p<0.01$, $d=0.41$). As mentioned above, FR intervention has been reported to increase pain tolerance[26,27]. In a previous review, the effect of FR on pain was reported to decrease spinal cord excitability and reduce pain[28]. Another systematic review suggests that rolling muscle and skin stimulation may increase temperature, and pressure stimulation of tissues is associated with increased pain thresholds[29]. In addition, the skin and fascia have been found to be highly innervated by sensory neurons, including Ruffini and Pacinian receptors, which may have the ability to inhibit sympathetic activity and induce muscle relaxation. Ruffini receptors, in particular, are sensitive to tangential force and lateral stretch, and it has been hypothesized that stimulation of these receptors through RM may improve pain and flexibility[15,30]. Therefore, RM intervention could be a way to relieve pain in TKA patients. In addition, it would appear that the effectiveness of FR intervention is comparable to that of stretching[10,15]. Therefore, we believe that RM intervention could effectively reduce pain and increase ROM after TKA in a clinical setting.

This study investigated the acute effects of RM intervention only. Previous studies have reported a significant increase in ROM after 5 or 6 weeks of an FR training program[31,32]. It has also been reported that an FR training program can decrease pain in patients with hip joint OA[17] and fibromyalgia[18]. A recent meta-analysis suggested that an FR training program of more than 4 weeks duration is necessary to increase ROM[11]. Therefore, it is possible that an RM training program lasting a number of weeks could increase ROM and relieve pain in TKA patients.

There were some limitations in this study. Firstly, this study is that there is no control group, so it is not sufficient to confirm whether RM is the only treatment effect. However, the measurement's reproducibility was highly reproducible under the same conditions as at the time of the measurement. The changes before and after RM in this study are larger than the SEM. Therefore, we believe that this change is due to the RM intervention. Secondly, we did not investigate the sustained effect of RM intervention. Therefore, therapists must investigate the sustained effect of RM intervention on ROM and pain in older adults with TKA. In this study, a detailed setting of the RM pressure was not possible, and it is possible that variations may have occurred. In the future, examining the treatment effects of different RM pressures will be necessary.

In conclusion, we investigated the acute effect of a single bout of 180-s RM intervention on ROM and pain in TKA patients in the second postoperative week. Knee flexion ROM increased significantly immediately after the RM intervention ($p<0.01$, $d=0.412$). Pain during knee flexion ROM measurements also decreased significantly compared to before the RM intervention ($p<0.01$, $d=-0.53$). However, the results were based on the same subjects, and the effect of treatment with and without RM intervention could not be verified. In the future, we would like to establish a comparison group to investigate the effect of RM on TKA patients

*Ethics Approval*

*An ethical review was conducted after obtaining approval from the Ethical Review Committee of Takeda General Hospital (approval number: 292).*

*Funding*

*This work was supported by JSPS KAKENHI with grant number 19K19890 (Masatoshi Nakamura).*

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