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ORIGINAL ARTICLE

Randomized Controlled Trial of the Effectiveness of Continuous Passive Motion After Total Knee Replacement

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Abstract

Objective: To determine the effects of using a continuous passive motion (CPM) device for individuals with poor range of motion (ROM) after a total knee replacement (TKR) admitted for postacute rehabilitation.

Design: Randomized controlled trial.

Setting: Inpatient rehabilitation facility (IRF).

Participants: Adults (N=141) after TKR with initial active knee flexion <75° on admission to the IRF.

Intervention: Two randomized groups: group 1 (n=71) received the conventional 3 hours of therapy per day, and group 2 (n=70) received the addition of daily CPM use for 2 hours throughout their length of stay.

Main Outcome Measures: The primary outcome measure was active knee flexion ROM. Secondary outcome measures included active knee extension ROM length of stay, estimate of function using the FIM and Timed Up and Go test, girth measurement, and self-reported Western Ontario and McMaster Universities Osteoarthritis Index scores.

Results: All subjects significantly improved from admission to discharge in all outcome measures. However, there were no statistically significant differences in any of the discharge outcome measures of the CPM group compared with the non-CPM group.

Conclusions: CPM does not provide an additional benefit over the conventional interventions used in an IRF for patient after TKR, specifically in patients with poor initial knee flexion ROM after surgery.

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Total knee replacement (TKR) surgery is a common surgical procedure used to reduce pain and improve function for individuals suffering from knee impairment associated with end-stage osteoarthritis. The number of TKR surgeries will rise to 3.5 million in the United States by the year 2030,[1] which will create considerable demand for rehabilitation services. Continuous passive motion (CPM) is a typical intervention added to the physical therapy (PT) services in acute care hospitals to encourage early knee motion; however, within postacute rehabilitation, its use is controversial.

The goal of rehabilitation after TKR is to facilitate the patient's return to an active lifestyle. Adequate range of motion (ROM) after surgery is linked to the performance of functional activities. CPM treatment has been used since the early 1980s to promote early mobilization and improve knee flexion ROM. From a theoretical perspective, the passive exercise provided by the CPM helps maintain ROM and reduces edema. Increased ROM enables active exercise and greater strengthening.[2] Adequate ROM to perform many activities of daily living (ADL) has been identified[3]: 90° to descend stairs, 105° to rise from a toilet or low chair,[4] and 106° to tie shoes.[5] The incidence of postoperative stiffness appears to be 8% to 12%; that of complete fibrous ankylosis after

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TKR is <1%.[6,7] Although many factors affect ROM after surgery, Bong,[8] Ritter,[9] and colleagues identified preoperative risk factors, such as limited ROM, underlying osteoarthritis, prior knee surgery, and knee deformity (varus, valgus, flexion contractures).

Studies have reported conflicting results regarding the effectiveness of CPM. Early work comparing CPM application after TKR with an immobilized knee postoperatively demonstrated improvement in knee ROM[10] and wound healing with CPM.[11] Other studies supported its use when applied immediately after surgery.[12-16] The positive results of immediate CPM application were for the short term. An equal number of studies refuted these findings and found CPM to be of little value in rehabilitation after TKR surgery.[17-25] These earlier works demonstrating improvements in ROM and reduction in length of stay (LOS) frequently compared the outcomes of patients using CPM with those with immobilized knees; however, immobilization is not contemporary practice. When additional outcomes, such as calf swelling, wound healing, and functional tests (eg, Timed Up and Go [TUG]), and subjective measures (eg, Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC] and Knee Society Score[26]) were analyzed, researchers similarly concluded that CPM offers no additional benefit.[27] All initial studies were done in the acute care hospital but were conducted using a variety of ROM settings, treatment times, and days of use.

To summarize the evidence, 3 systematic reviews were conducted. Two reviews favored the use of CPM in the initial postoperative phase after TKR[2,28]; a later Cochrane review did not.[29] The Brosseau et al[2] review suggested that CPM combined with PT intervention increased active knee flexion by 4° at 2 weeks post-knee replacement relative to PT alone. The meta-analysis reviewed 20 randomized controlled trials of 1335 patients and reported similar findings. CPM use in acute care hospitals may offer a small short-term, but not long-term,[30] benefit. Its use needs to be carefully weighed against the inconvenience and expense. However, these reviews were conducted in acute care settings or in the home, and none involved patients receiving rehabilitation at an inpatient rehabilitation facility (IRF).

One prospective study compared patients randomly assigned to either a CPM group or a non-CPM group and found no differences between groups.[31] A second IRF-based study compared a control group receiving PT alone with 2 experimental groups (one received 35min of CPM, the other received 2h as an adjunct to PT treatment). The results did not support the addition of CPM in the rehabilitation setting.[17] In our prior work,[32] using a matched cohort design, we reported no differences in ROM gain, FIM, ambulation device use, or the need for homecare after discharge in 126 matched patients in an IRF setting.

Although the preponderance of evidence does not support the benefit of CPM, no prior CPM study, to our knowledge, conducted in an IRF selected patients most at risk for poor knee ROM after a TKR. The purpose of this study was to determine the effects of using a CPM device for individuals with poor ROM after a TKR who were admitted for postacute rehabilitation.

List of abbreviations:

ADL	**activities of daily living**
ANCOVA	**analysis of covariance**
AROM	**active range of motion**
CPM	**continuous passive motion**
ICC	**intraclass correlation coefficient**
IRF	**inpatient rehabilitation facility**
LOS	**length of stay**
PT	**physical therapy**
ROM	**range of motion**
TKR	**total knee replacement**
TUG	**Timed Up and Go**
WOMAC	**Western Ontario and McMaster Universities Osteoarthritis Index**

Methods

Participants

All patients transferred directly to the IRF within 5 days after their surgery between November 2011 and November 2012 were assigned a primary therapist who assessed the patient's active knee flexion and extension ROM on the day of admission. Patients were enrolled consecutively according to the following inclusion criteria: (1) transferred to an IRF after a single knee replacement; (2) etiology of osteoarthritis; (3) aged 40 to 80 years; (4) initial maximal knee flexion ROM between 45° and 75° of flexion; and (5) body mass index <40. Exclusion criteria were as follows: (1) revision to a previous TKR; (2) bilateral TKR; and (3) comorbid medical conditions that could interfere or complicate recovery (eg, stroke, Parkinson's disease, significant cognitive impairment). The institutional review board approved the study, and written informed consent was obtained for each participant. Consented subjects were randomly assigned to either the control or experimental group based on their unique, episode-specific account number. The control group received conventional PT. The experimental group received conventional PT and daily CPM application for 2 hours. With a medium effect size of .50 and a desired power of .80, the minimum acceptable sample size was 65 persons per group for a total of 130 subjects. The patients and therapists were not blinded to the study group.

We defined conventional therapy as 3 hours per day of PT and occupational therapy as part of the interdisciplinary plan of care. The experimental group received an additional 2 hours per day of CPM. On the day of admission, the CPM machine was set based on the maximum flexion tolerated, and the extension was set at 0°. The patients were instructed about how to stop the machine if they experienced more than minimal discomfort.

During the initial PT evaluation, the patients were assessed on each of the study variables. The discharge date and discharge destination were determined by the physician-led interdisciplinary team, who were blinded to the group assignment. On the day prior to discharge, the outcome variables were reassessed. LOS was calculated by subtracting the discharge date from the admission date to the IRF. One week after discharge, the WOMAC survey was mailed to the patient's home. Follow-up phone calls were made to facilitate survey return.

Measures

The outcome measures studied were active range of motion (AROM), TUG score, knee girth, total FIM scores, ambulation device at discharge, LOS, and self-reported WOMAC score.

AROM measurement was taken with a universal goniometer. Its axis was placed in line with the center of the knee, the fixed arm aligned with the greater trochanter, and the mobile arm aligned with the lateral malleolus. Both flexion and extension ROMs were measured in the supine position. Intertester reliability