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Original Article

Comparison of the long-term effectiveness of progressive neuromuscular facilitation and continuous passive motion therapies after total knee arthroplasty

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Abstract. [Purpose] The aim of this longitudinal study was to examine the long term functional effectiveness of proprioceptive neuromuscular facilitation (PNF) after total knee arthroplasty. [Subjects and Methods] We included 30 patients and they were randomly assigned to two groups. In addition to the standard rehabilitation program the PNF group received proprioceptive neuromuscular facilitation therapy and the CPM group received continuous passive motion therapy. The outcome measures included range of motion using a goniometer, pain scores using a numeric pain rating scale, days to reach functional benchmarks, the Beck depression scale and isokinetic torque and isometric strength measurements. [Results] There were no significant differences between the two groups in terms of baseline demographic data, clinical findings and length of stay. Days to reach range of motion benchmarks were similar in the two groups. Pain at the 8th week was slightly higher in the PNF group. With the exception of walking with a walker, days to reach functional benchmarks were statistically significantly fewer in patients of the PNF group despite similar isokinetic measurements. Administration of PNF resulted in earlier functional gains in patients after total knee arthroplasty. These functional accomplishments were more pronounced in the PNF group despite it having isokinetic torque measurements similar to those of the CPM group. [Conclusion] PNF techniques can positively affect functional outcomes over the long term.
Key words: Functional gains, Proprioceptive neuromuscular facilitation, Total knee arthroplasty

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INTRODUCTION

Reaching maximum possible knee range of motion (ROM) and attaining certain functional milestones remain the mainstay of rehabilitation following total knee arthroplasty (TKA). ROM constitutes one of the most important outcomes following TKA since patients with less than 105° knee ROM have difficulty going up and down the stairs or getting out of a low chair[1)]. Restricted postoperative knee flexion is one of the most frequent postoperative complications and is an indicator of patient dissatisfaction[2)].

After Salter et al.[3)] demonstrated the beneficial effects of continuous passive motion (CPM) on articular cartilage defect healing in rabbits, various studies have investigated the effectiveness of CPM. Despite controversies it has been regarded as a standard postoperative management tool, since CPM offers short-term benefits[4, 5)]; however, its long term effectiveness remains obscure. Postel et al. suggested the comparison of alternative intermittent mobilization techniques with CPM[6)]; however, few studies have addressed this issue. Chow et al. have assessed the effects of active, passive and proprioceptive neuromuscular facilitation (PNF) stretching for patients with TKA on ROM in the early postoperative period[7)], but the long term effectiveness or benefits of mobilization techniques on functional parameters has not been investigated.

PNF exercises involving agonist and antagonist muscles are designed to promote the neuromuscular responses of the proprioceptors and are frequently used in the clinics to relieve pain and increase ROM for various ailments. It is an attractive method for increasing strength and proprioception in elderly individuals[8)]; and may have additional benefits in addition to increasing ROM. In this study, the long term functional effectiveness of PNF was investigated from various aspects with a special emphasis on the functional point of view.

SUBJECTS AND METHODS

Thirty subjects who underwent TKA in the Department of Orthopaedic Surgery, Marmara University for a diagnosis of osteoarthritis were included in this study. Patients with

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infection of the affected knee, neuromuscular problems, psychiatric disorders or cardiac problems were excluded. After surgery patients were randomly assigned to either PNF (Group 1) or CPM (Group 2) treatment groups. Patients were treated everyday during their hospital stay, 3 times/week after discharge for 2 months, 1/week in the following 2 months, and performed home exercises in the remaining days. They were followed by the same physiotherapist.

In addition to the standard TKA rehabilitation program[9] including pain control, knee mobilization, exercises, transfer, mobility, the PNF group received PNF therapy and the CPM group received CPM therapy lasting 1 hour similar to the intervention of Denis et al[10].

After detailed instruction of the procedure, patients in the PNF group were placed supine and were asked to follow the exercises with visual feedback. They performed 3 sets of 5 repetitions of the rhythmic initiation technique[11] starting from the first postoperative day. After a patient became competent in performing in exercises in both directions, leg patterns in the sitting position were commenced. A combination of isotonics (described by Gregg Johnson and Vicky Saliba)[11] and 3 sets of 5 repetitions of the rhythmic stabilisation technique were performed. Each contraction was held for 6 seconds with alternation between the agonist and antagonist muscles[12].

For the CPM group after 5 minutes warm-up, ROM was set as tolerated by the patient. The CPM protocol was started with 0° to the maximum tolerated flexion angle, depending on the tolerance of the patient. Participants were instructed not to interfere with the movement of the CPM device.

For each participant, anthropometric, personal, and clinical characteristics were recorded, including gender, age, weight, height, social status, comorbid conditions, previous disease or surgeries, and time from the onset of symptoms.

The ROM measurement was taken every day with a 1-degree-increment goniometer. Its center of rotation was placed in line with the center of the knee, the fixed arm was aligned with the greater trochanter, and the mobile arm aligned with the lateral malleolus. Measurements were recorded with respect to full extension being 0 degree with positive numbers indicating a more flexed position and negative numbers indicating hyperextension. The criterion validity and the intra- and inter-rater reliabilities of data obtained with the goniometer have been demonstrated to be high[13]. In addition to the baseline values, we noted the days to reach ROM benchmarks of 45, 60, 90 and 100 degrees of flexion (active and passive), and extension deficits of 20 and 5 degrees.

Pain scores were measured using a Numeric Pain Rating Scale (NPRS) similar to Chow et al., with 0 indicating no pain and 10 indicating the worst imaginable pain[7]. The patient was asked to answer the following question: "How intense is the pain in your knee now?" The patients selected the number that best reflected the intensity of the pain. Pain was assessed at weeks 1, 2, 8 and 16. Knee circumference was measured at the center of patella and noted at the ends of weeks 1, 2, 8 and 16[7]. The days to reach functional benchmarks such as: pain free use of a walker, double and single canadian use and walking 100 meters without using an aid were recorded, and assessments using the Beck depression scale at baseline and at the end of the study period were also performed.

Four months after the surgery, isokinetic torque and isometric strength measurements were performed using a Cybex 350 isokinetic dynamometer. The bilateral quadriceps and hamstring muscle strengths were measured at 4 months after surgery; our time frame was similar to Lauermann et al[14]. Patients were seated on the dynamometer chair (Cybex 350) with a trunk-thigh angle of 90°. Body, pelvis and thighs were secured with straps. Visual and verbal feedback was provided to the patients. (1) For the isometric strength measurement, the patients were asked to contract the quadriceps and hamstring muscle as forcefully as possible for 5 seconds separated by 20 seconds of rest for 4 times. Muscle strength was measured isometrically at 30° and 60°. The highest MVC torque from four trials was evaluated. (2) Isokinetic concentric peak torque was evaluated at an angular velocity of 60°/s, for 4 times separated by 20 seconds of rest. The peak torque from each of four consecutive trials was used in the analysis.

The study was reviewed and approved by the ethical committee of Marmara University and the patients provided informed consent.

RESULTS

There were no significant differences between the two groups in terms of baseline demographic data and clinical findings (Table 1, $p \geq 0.05$). Mean length of stay (LOS) of the patients was 14.17±2.46 days, and it was similar in the two treatment groups ($p=0.54$). The numbers of patients who could gain 90 degrees of flexion at discharge were the same in both groups; 4 patients in each group were able to attain this goal ($p>0.05$). However, when the patients who could gain 90 degrees knee flexion earlier were compared with those who could not, their BMI was found to be statistically significantly less ($p=0.03$).

Days to reach ROM benchmarks were similar in the two groups ($p>0.05$), except for that of 90 degrees of active flexion. The PNF group reached the 90 degree benchmark in 16.67±7.06 days, whereas the CPM group reached it in 23.73±9.26 days ($p=0.04$). Days to reach important ROM benchmarks are summarized in Table 2. In the PNF group, 12 patients were able to reach 100 degrees, and 3 did not; in the CPM group, 11 patients were able to reach 100 degrees, and 4 did not ($p>0.05$).

In terms of pain, NPRS at the 8th week was slightly higher in the PNF group; the mean NPRS of PNF patients was 1.07±1.58 and that of the CPM group was 0.67±0.26 ($p=0.025$).

With the exception of walking with a walker, days to reach functional benchmarks were statistically significantly earlier in patients of the PNF group ($p=0.01$) (Table 3).

The Beck depression scores, circumferential measurements of the knee and isokinetic measurements were similar in the two groups ($p>0.05$).

DISCUSSION

In addition to ROM improvements, the patients treated with PNF showed earlier functional gains after TKA. These

Table 1. Demographic data of the patients recruited for the study (N=30)

	Group 1 (n=15)	Group 2 (n=15)
Female/male	14/1	12/3
Mean age (SD) (years)	68.67 (7.27) Range: 53–75	68.07 (6.89) Range: 58–76
Mean BMI (SD)	28.87 (3.74) Range: 23–37	31.13 (5.18) Range: 21–40
Side of surgery left/right	5/10	8/7
Baseline active flexion (SD) (degrees)	38 (12.93)	47 (14.12)
Baseline passive flexion (SD) (degrees)	46 (13.4)	54 (13.56)
Baseline NPRS (SD)	6.07 (1.28)	7 (1.07)
Baseline Beck score (SD)	16.4 (6.7)	13.4 (3.14)
Baseline knee circumference (SD) (cm)	43.74 (2.15)	44.6 (2.13)

BMI: body mass index, NPRS: numeric pain rating scale

Table 2 . Days to reach important ROM benchmarks

ROM benchmark	Group 1 (PNF) (degrees)	Group 2 (CPM) (degrees)
Active flexion		
Baseline	38±12.93	47±14.12
Days to reach 45 degrees	4.33±1.63	3.8±1.97
Days to reach 60 degress	8.20±2.86	9.53±3.48
Days to reach 90 degrees	16.67±7.06*	23.73±9.26*
Passive flexion		
Baseline	46±13.4	54.67±13.56
Days to reach 45 degrees	3.93±0.88	4.13±0.83
Days to reach 60 degress	5.93±1.53	6.8±1.26
Days to reach 90 degrees	14.6±4.47	17.53±4.91
Extension		
Days to reach 20 degrees	1.27±0.8	2.27±2.12
Days to reach 5 degrees	16.6±9.49	20.8±10

*p<0.05, statistically significant

Table 3. Days to reach functional benchmarks

Functional benchmarks	Group 1 (PNF) (days)	Group 2 (CPM) (days)
Walker	3.93±0.59	4.4±0.63
Double canadian	13.07±2.94*	16.53±3.4*
Single canadian	27.2±3.57*	41.67±4.88*
Aid free walking	45.33±6.94*	59.53±5.9*

* p<0.05, statistically significant

functional accomplishments were more pronounced in the PNF group despite similar isokinetic torque measurements. Also, earlier recovery was demonstrated by patients with lower BMI values independent of the treatment. Obesity is a known risk factor of osteoarthritis[15]. Our findings are in agreement with Jarvenpaa et al.[16], who has demonstrated that obesity may delay the recovery from TKA.

Despite controversies; CPM remains widely used in rehabilitation following TKA surgery, to accelerate recovery. Various protocols for CPM have been described in the literature; however, using CPM for long hours is not practical in clinical practice. In the present study, CPM was administered following Denis et al.[10], and similar to their findings, LOS was similar in the two treatment groups.

CPM has been argued against since it is a passive mobilization and does not encourage patients to actively participate in their rehabilitation[17]. In a study involving 132 subjects with knee osteoarthritis, it was demonstrated that PNF techniques were more effective than static stretching[18]. Minshull et al. have demonstrated that PNF is as equally efficious for flexibility conditioning as compared to passive stretching, and they suggested it should be used in preference to passive stretching to preserve dynamic joint stability[19].

Studies have noted out the close relationship between ROM, function, and quality of life in older patients. Stanziano et al. have examined the effects of an 8 week active-assisted stretching program on functionality, mobility, power and ROM in elderly residents of a residential retirement community and concluded that this type of exercise is beneficial for the elderly who have insufficient physical reserves to perform higher-intensity exercises[20]. PNF has been used with caution for the elderly since it involves close-to-maximal loads and isometric contractions; however, Pereira et al. have studied the effect of PNF on the diastolic and systolic blood pressures of the elderly and concluded that this technique is safe[8].

The PNF group was able to reach functional benchmarks earlier than the CPM group; however, isokinetic measurements were similar in the two groups. A 6 week PNF stretching program for 49 volunteers has been demonstrated that it increased ROM and decreased tendon stiffness, despite the absence of change in passive resistive torque[21]. Similarly Konrad et al. and Higgs et al. reported that a 4 week quadriceps flexibility training program improved knee ROM without altering muscle isokinetic strength characteristics[21, 22]. According to these findings, elderly patients benefit from active-assisted stretching, which is a form of PNF, in terms of both ROM and performance measures. Thus PNF improves the functional performance of elderly patients with insufficient reserves to perform higher-intensity exercises[20]. Gonzalez-Rave have compared passive versus propriocep-

tive stretching using elderly subjects and concluded that the ROM gain was similar for both techniques however, they didn't perform functional measures[23].

Lauermann et al. asserted that open chain mono-articular testing may not reflect functional activities of living[14]. In agreement with this, the results of the present study demonstrate increased ROM and accelerated functional recovery without change in peak isokinetic torque.

The short term effects of neuromuscular joint facilitation treatment, which integrates a facilitation component of PNF, have previously been demonstrated. This treatment have led to increased walking velocity, step length and decreased cadence as well as decreased pain in patients with osteoarthritis of the knee[24]. The advantage of our study is that patients were followed for a long period of time, they were evaluated from the various standing points of ROM, functional gains, isokinetic measurements and psychological variables. The number of subjects included in this study were limited by the demands of PNF and the workload of the physiotherapist. Additionally, we were unable to include a control group since CPM is widely known in our country and was requested by the patients.

The present study is the first study to demonstrate the beneficial effects of PNF from a functional point of view in a prospective long term setting. Further studies of the effects of PNF using larger patient groups may help to optimize the postoperative rehabilitation of the TKA patients.

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