



Original Article

# The effects of posterior talar glide with dorsiflexion of the ankle on mobility, muscle strength and balance in stroke patients: a randomised controlled trial

JIN LEE, PT, MSc<sup>1)</sup>, JU-O KIM, PT, MSc<sup>1)</sup>, BYOUNG-HEE LEE, PT, PhD<sup>2)\*</sup>

<sup>1)</sup> Graduate School of Physical Therapy, Sahmyook University, Republic of Korea

<sup>2)</sup> Department of Physical Therapy, Sahmyook University: 815 Hwarang-ro, Nowon-gu, Seoul 139-742, Republic of Korea

**Abstract.** [Purpose] The purpose of this study was to examine the effectiveness of posterior talar glide (PTG) with dorsiflexion of the ankle on stroke patients ankle mobility, muscle strength, and balance ability. [Subjects and Methods] Thirty-four subjects were randomly assigned to either a PTG with dorsiflexion group (PTG; n=17), or a weight-bearing with placebo PTG group (control; n=17). Subjects in the PTG group performed PTG with dorsiflexion, designed to improve ankle mobility, muscle strength and balance ability with proprioceptive control of the ankle, for 10 glides of 5 sets/day, 5 days/week, for 4 weeks. [Results] The experimental group showed significant improvement on the Ankle Dorsiflexion Range of Motion assessment, Ankle Dorsiflexor Manual Muscle Test, Functional Reach Test, Time Up and Go test, and Functional Gait Assessment compared to the control group. However, regarding Ankle Plantarflexion Range of Motion assessment and the Ankle Plantarflexor Manual Muscle Test, no significant differences were found between the two groups. [Conclusion] The results of this study show that PTG with dorsiflexion can improve ankle mobility, muscle strength and balance ability in patients recovering from stroke. This exercise may prove useful in clinical rehabilitation. Further research on the long-term effectiveness of PTG on gait ability is suggested.

**Key words:** Stroke rehabilitation, Posterior talar glide with dorsiflexion, Balance

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## INTRODUCTION

Following stroke, difficulties in controlling balance may be caused by several factors, such as muscle weakness, impaired proprioception, asymmetric weight bearing, spasticity, and impaired motor control<sup>1)</sup>. Balance disorders due to deficits in multiple mechanisms are frequently encountered in patients with stroke. Balance is an important predictor of outcome in stroke rehabilitation<sup>2)</sup>.

Due to the weakness of dorsiflexors, foot drop is common in stroke patients<sup>3)</sup>. The shortening of calf muscles in individuals with stroke causes stiffness, worsened hypomobility, joint mobility resistance, and decreased passive joint mobility-resulting in the limitation of ankle joint motion<sup>4)</sup>. Abnormal muscle tensions and movement limitations due to muscle weakness at the ankle joint cause limitation of functional activities such as sit-to-stand, locomotion, and stair-climbing<sup>5)</sup>. Functional weakness of the lower extremity due to stroke is caused not only by muscular weakness, but also by decreases in muscular endurance and stability of the joint, and loss of proprioceptive sense<sup>6)</sup>. Clinically, proprioceptive sense is an important factor in the evaluation and treatment of patients with neurologic problems; its loss leads to declines in postural control, protective

\*Corresponding author. Byoung-Hee Lee (E-mail: 3679@syu.ac.kr)

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reflexes, joint movement, balance ability, and gait<sup>6</sup>). Therefore, improving balance and gait function is one of the most important goals in patients undergoing stroke rehabilitation. Many different types of physical therapy are used to improve balance in stroke rehabilitation.

The Mulligan technique for posterior talar glide (PTG) with dorsiflexion of the ankle has been applied to improve range of motion, alleviate pain, and promote earlier return to function following lateral ankle sprain<sup>7</sup>. The Mobilization with Movement (MWM) technique is frequently used to improve talocrural dorsiflexion deficits that are often seen following lateral ankle sprain<sup>8</sup>. A key component of the MWM treatment technique postulated to improve talocrural dorsiflexion is a PTG that is applied manually to the joint<sup>7</sup>. Previous studies of the Mulligan technique were conducted in patients with musculoskeletal disorders<sup>8</sup>. However, the application of the Mulligan technique to PTG with dorsiflexion of the ankle for treating stroke patients had not yet been assessed.

Thus, the purpose of the present study was to demonstrate that PTG with dorsiflexion of the ankle improves ankle range of motion, along with muscle strength and balance in stroke patients.

## SUBJECTS AND METHODS

Thirty-four chronic stroke patients voluntarily participated in the study. Subjects met the following inclusion criteria: History of stroke onset >6 months prior to the study, in order to minimise the effects of natural recovery; Mini-Mental State Examination score of >24 out of 30; motor recovery of the paretic lower limb to within Brünstrom stages 2–4; and ability to comprehend and follow simple instructions. Individuals were excluded if they had a neurological condition, an orthopedic disease, or a visual impairment. The 34 subjects were randomly assigned to either the ‘PTG with dorsiflexion’ group (PTG; n=17), or the ‘weight-bearing with placebo PTG’ group (control; n=17).

There were 17 subjects in the experimental group (8 males and 9 females), with a mean age of 58.00, a mean height of  $162.06 \pm 7.37$  cm, and a mean weight of  $61.00 \pm 8.55$  kg; there were 17 subjects in the control group (13 males and 4 females), with a mean age of  $51.59 \pm 13.31$ , a mean height of  $166.53 \pm 6.85$  cm, and a mean weight of  $64.71 \pm 7.54$  kg. There were no significant differences between the groups (Table 1). The present study was approved by Sahmyook University Institutional Review Board and each participant was able to follow instructions and gave informed consent by signing an approved consent form; thus, the rights of human subjects were protected.

All subjects were assessed using Passive Range of Motion of the ankle (ROM), a Manual Muscle Test (MMT), a Functional Reach Test (FRT), a Time Up and Go test (TUG), and a Functional Gait Assessment (FGA).

PTG treatment with dorsiflexion of the ankle joint consisted of a program to improve range of motion, and to promote functional recovery and balance ability through proprioceptive control of the ankle. The program consisted of gliding and resting. Patients in the PTG group underwent treatment with dorsiflexion of the ankle joint for 10 glides of 5 sets/day, 5 days/week, for 4 weeks. Each glide consisted of a 10-s PTG with dorsiflexion and 5 s of rest between glides. Grade III movements were used for each glide. The therapist applied a sustained posteroanterior glide to the tibia using a belt by leaning backwards while the talus and forefoot were fixed with the thumb and right second finger. The other hand was positioned anteriorly over the proximal tibia to direct the knee over the line of the second and third toes. Then the participant was instructed to perform a slow dorsiflexion movement until either the first onset of pain or the end range of motion, without the heel lifted off the couch. To avoid pain at the contact point of the belt with the Achilles tendon, foam cushioning was used.

For the control group, the participant was instructed to perform a slow dorsiflexion movement until the first onset of pain or end range of motion without the heel lifted off the couch. The control group was trained for 10 lunges of 5 sets/day, 5 days/week, for 4 weeks. Both groups also underwent standard rehabilitation physical therapy for 30 min/day, 5 days/week, for 4 weeks. The standard rehabilitation physical therapy program included neurodevelopmental treatment.

Balance ability was assessed using the FRT, TUG, and FGA. The FRT is based on analysing the limits of anterior-posterior stability in an upright position, in the absence of external perturbations. It assesses the maximum forward displacement (in cm) that a subjects can reach without losing balance<sup>9</sup>. Balance was assessed using the TUG and FGA. The TUG is a functional flexibility test invented by Podsiadlo and Richardson<sup>10</sup>. It was designed as a quick measure of the basic balance and mobility skill of stroke patients. the time taken for subjects to rise from an armchair, walk 3m, turn, and return to the chair is measure in seconds. FGA is used to evaluate postural stabilization during gait. It was initially invented for the stroke patients who had great risk of falling down. In this study, the original form of FGA was properly revised with an addition of three items in Dynamic Gait Index<sup>11</sup>. Passive ROM of the ankle was measured using the digital goniometer.

SPSS 19.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. The Kolmogorov-Smirnov test was used to test the distribution of general characteristics and outcome measures of the subjects. A paired t-test was used to compare pre- and posttest measurements of ankle ROM and balance within groups, and the independent t-test was used to compare the difference in ankle ROM and balance before and after training between groups. A Wilcoxon's signed-ranks test was used to compare pre- and posttest measurements of ankle MMT within groups, and Mann-Whitney U test was used to compare the difference in ankle MMT before and after training between groups. The significance level was set at 0.05 for all analyses.

**Table 1.** Characteristics of the participants (N=34)

	PTG (n=17)	Control group (n=17)
Gender (male/female)	8/9	13/4
Affected side (Rt/Lt)	7/10	8/9
Age (years)	58.0 ± 3.1	51.6 ± 3.2
Height (cm)	162.1 ± 7.4	166.5 ± 6.9
Weight (kg)	58.0 ± 12.9	51.6 ± 13.3

Values are expressed as mean ± standard deviation (SD), PTG: Posterior Talar Glide with Dorsiflexion group

**Table 2.** Comparison of ankle range of motion, muscle strength, and balance as measured within groups and between groups (N=34)

Parameters	Values				Change Values	
	PTG (n=17)		Control group (n=17)		PTG (n=17)	Control group (n=17)
	Pre	Post	Pre	Post	Post-Pre	Post-Pre
<b>Balance</b>						
FRT Rt. (cm)	15.7 (7.6) <sup>a</sup>	17.7 (7.7)***	19.2 (6.1)	19.8 (6.0)**	2.0 (1.5)*	0.6 (0.8)
FRT Lt. (cm)	15.1 (6.4)	16.8 (6.4)***	18.1 (6.9)	18.7 (7.0)*	1.7 (0.8)***	0.6 (0.9)
TUG (sec)	13 (3.2)	11.3 (2.9)***	12.5 (2.8)	11.4 (2.7)***	-1.7 (0.7)*	-1.1 (0.8)
FGA (score)	19.8 (5.4)	21.2 (4.4)***	20.9 (2.5)	21.5 (2.3)**	1.4 (1.3)*	0.6 (0.6)
<b>Muscle Strength</b>						
Dorsiflexor MMT (scale)	3.12 (1.83)	3.53 (1.41)**	3.35 (1.93)	3.47 (1.80)	0.23 (0.43)	0.17 (0.48)
Plantarflexor MMT (scale)	3.29 (1.61)	3.59 (1.50)	3.53 (1.83)	3.59 (1.83)	0.29 (0.58)	0.11 (0.48)
<b>Ankle ROM</b>						
Dorsiflexion (angle)	14.1 (9.1)	17.1 (5.0)*	18.8 (3.8)	19.4 (2.4)	2.9 (4.4)*	0.3 (1.2)
Plantarflexion (angle)	41.2 (9.1)	43.5 (4.2)	43.2 (6.1)	43.2 (6.1)	2.4 (5.3)	0.0 (0.0)

<sup>a</sup> Values are Mean (SD), PTG: Posterior Talar Glide with Dorsiflexion group, FRT: Functional Reach Test, TUG: Time Up and Go, FGA: Functional Gait Assessment, MMT: Manual Muscle Testing, Ankle ROM: Ankle Range of Motion. \*p<0.05, \*\*p<0.01, \*\*\*p<0.001

## RESULTS

In the PTG group, passive dorsiflexion ROM of the ankle, along with FRT, TUG and FGA, was significantly improved. There were significant differences between the groups for these variables (p<0.05). Ankle dorsiflexor MMT in the PTG group is significantly improved (p<0.05). However, with regards either to passive plantarflexion ROM of the ankle, or to plantar and dorsiflexor MMT, there were no significant difference between the groups (Table 2).

## DISCUSSION

Stroke and brain injury are diagnoses in the rehabilitation setting that often lead to decreased mobility. Once a person is less mobile, more time is spent in resting positions that can predispose them to muscle shortening, which can impact recovery of function<sup>12)</sup> and can result in a significant decrease in ankle dorsiflexion ROM after a stroke<sup>13)</sup>.

In this study, the PTG group underwent PTG with dorsiflexion for 10 glides of 5 sets/day, 5 days/week, for 4 weeks. The PTG group showed a significant improvement in passive dorsiflexion ROM of the ankle and dorsiflexor MMT (p<0.05); the control group showed no significant improvement in passive dorsiflexion ROM of the ankle and dorsiflexor MMT. However, with regard to dorsiflexor MMT of the ankle, there were no significant differences between the groups.

An and Jo<sup>14)</sup> Twenty-six participants with chronic hemiplegia were divided into 2 groups: the MWM group (n=13) and the control group (n=13). Both groups attended conventional physiotherapy sessions 3 times a week for 5 weeks. Additionally, the MWM group underwent talocrural mobilization with movement (MWM) 3 times a week for 5 weeks. Passive dorsiflexion ROM of the ankle significantly increased in the MWM group (p<0.05).

Posterior Talar Glide with Dorsiflexion facilitated the recovery of accessory movement in the talocrural joint. Triceps surae muscle stretch was obtained through sustained and repeated maximal ankle dorsiflexion ROM during mobilization<sup>15)</sup>.

Muscle weakness, including weakness of the affected ankle dorsiflexors and plantarflexors, is common following stroke.

It could be attributed to physiological changes in motor systems, including failures in motor unit recruitment and a reduced firing frequency of agonist motor neurones or units<sup>16)</sup>. Spasticity in the ankle plantarflexors might impede their ability to generate appropriate muscle force as agonists during ankle plantarflexion. It could also act as an active restraint during ankle dorsiflexion<sup>17)</sup>.

Balance is the ability to maintain the center of gravity from a base of support with continuity<sup>18)</sup>, and is a component of prognosis for a stroke patient's functional recovery<sup>19)</sup>. The most important goal of rehabilitation for a stroke patient is independence of activity, thus, priority should be given to restoring equilibrium and posture stability for optimum functioning<sup>20)</sup>. Therefore, one of the most important aims of therapy is the improvement of equilibrium regulation and function<sup>21)</sup>.

In this study, The PTG group showed a significant improvement in FRT, TUG, and FGA; The control group demonstrated significant improvement in FRT, TUG, and FGA. The PTG with dorsiflexion group showed significantly greater improvement in FRT, TUG, and FGA ( $p < 0.05$ ) as compared to the control group, which suggests that PTG with dorsiflexion improves the balance ability of patients recovering from stroke.

McKeon et al.<sup>22)</sup> performed balance training 60 min/day for 4 weeks in 31 subjects who had been complaining of ankle instability. Their ability to move in an anteroposterior direction, their Center of Pressure (COP) while moving in a left or right direction with eyes open, and their total postural sway speed at the COP were considerably decreased ( $p < 0.05$ ). Hoch and McKeon<sup>23)</sup> performed joint manipulation in 20 patients with ankle instability, and the experimental group showed considerable improvement in anteroposterior postural control ( $p < 0.05$ ). The improvement in static balance in these reports corresponds to the findings of this study.

To reduce falls and improve equilibrium adequate range of motion is needed<sup>24)</sup>; The loss of somatosensory information the mechanical receptors near the ankle joint decreases postural control and results in the subsequent loss of static balance<sup>25)</sup>. Joint manipulation stimulates the afferent pathways of mechanical receptors near the ankle joint, and this stimulation improves afferent information of the talocrural articulation and the surrounding tissue<sup>25)</sup>. Hoch and McKeon<sup>23)</sup> stated that it is possible to control posture by joint mobilization through stimulation of the mechanical receptors surrounding the ankle joint. Improvement in postural control is due to neuromuscular function adjustment caused by mechanical receptor activity<sup>26)</sup>. For these reasons, this study demonstrates that an increase in joint range of motion and continuous PTG on the distal tibia with an active weight-bearing posture can increase afferent stimulation of the ankle joint and improve static balance with enhancement of neuromuscular function.

### Conflicts of interest

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

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