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Brief Report

Do traditionally recommended cane lengths equally influence walking in patients after stroke?

Yong-Jun Cha, Ph.D., P.T.

Department of Physical Therapy, College of Natural Science, Daejeon University, 62 Daehackro, Dong-Gu, Daejeon 302-111, Republic of Korea

Abstract

Background: A cane has been used to improve hemiplegic gait by assisting affected limb to smoothly shift body mass toward the sound limb.

Objective: The purpose of this study was to compare the walking parameters of patients after stroke while walking using traditionally recommended cane lengths that is fitted to the height of the greater trochanter (GT) or to the wrist crease (WC).

Methods: Sixteen patients with stroke participated in this study and were randomly assigned to walking with a GT or WC cane length. The two traditionally recommended cane lengths were from the ground to the top of the GT or to the distal WC. Measured walking parameters were foot contact area of the affected side, stride length, center of pressure trajectory, foot axis, foot pressures, and walking velocity when walking with a cane.

Results: Significant differences in foot contact area, foot pressure, and center of pressure trajectory were observed between the two cane lengths ($p < 0.05$). The GT cane length had a wider mid-foot contact area (by 19.7%), a longer anterior/posterior center of pressure trajectory (by 9.7%), a greater toe pressure (by 26.7%), and a greater mid-foot pressure (by 14.3%) than the WC cane length ($p < 0.05$). No significant differences were observed for other walking parameters.

Conclusion: Hemiplegic walking with cane fitted at the GT might results in more normal walking of the affected limb in patients after stroke.

Keywords: Greater trochanter; Wrist crease; Cane; Walking; Stroke

Walking is important for patients after stroke because it plays a crucial role in the activities of daily living and the many tasks required for an independent life.[1] It has been well-documented that 57% of patients that survive stroke are unable to walk without human assistance for a week, cannot walk at normal speed and have a longer swing phase during walking due to insufficient hip flexor activity and low propulsion on the affected side.[1−3] Furthermore, they are at much risk of falling down than same aged controls.[4]

A cane improves hemiplegic gait by assisting the affected limb to smoothly shift body mass toward the sound limb and by enhancing inadequate shock absorption at heel strike and push off to maintain forward propulsion during the pre-swing phase.[5,6] For the proper usage of cane assistance, two guidelines have been issued for measuring the length of a cane in a clinical setting for independent walking. The two commonly used methods to determine the appropriate cane length are the distances from the ground to the greater trochanter or to the wrist crease. Some previous studies[7−10] have studied walking variables using a cane fitted using the distance from the greater trochanter to the ground, whereas others[11−15] used a cane fitted using the distance from the wrist crease to the ground.

All previously studies[7−15] on cane use have compared walking parameters, and have shown significant differences during walking with cane fitted to the greater trochanter or to the wrist crease. Although these studies produced good results for increasing function in patients after stroke, cane length *per se* may be an independent variable.

Some previous studies have investigated and compared walking parameters with respect to type of walking aid, shape of handle, and cane material.[15−18] However, few studies have compared plantar pressure distributions and spatiotemporal walking parameters for the two traditionally recommended cane lengths. Therefore, the purpose of this study was to compare walking parameters in patients after stroke using a cane fitted to the greater trochanter or the wrist crease during walking.

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Corresponding author: Tel.: +82 42 280 2292; fax: +82 42 280 2295.
E-mail address: cha0874@gmail.com

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Methods

Subjects

Patients after stroke ($n = 48$) were screened for this study. The inclusion criteria applied were; the ability to walk for at least 6 min using a mono-cane, the ability to comprehend simple commands, and a status enabling comprehensive rehabilitation immediately after stroke. Exclusion criteria were; the ability to walk 10 m without a cane, the use of a four-point cane or ankle-foot orthosis, a history of major injury, such as, fracture or surgery to the lower extremity, and a vestibular system disorder that increases the risk of falling.

Sixteen subjects met the study criteria. The general characteristics of these patients are listed in Table 1. Two patients had experienced falls since stroke. The motor and sensory statuses were obtained from patient history notes. Mean muscle tone of the paralyzed dorsiflexor according to the modified Ashworth scale was 0.9.[19] Nine patients were usually using a cane fitted at the GT and the others were using a cane fitted at the WC. Absolute cane lengths fitted at the GT were longer than those fitted at the WC.

The University of Daejeon Institutional Review Board granted approval for the study. All study subjects were informed of the purpose of this study and the experimental procedure, and all provided written informed consent prior to participation in accordance with the ethical standards of the Declaration of Helsinki.

Material and measurement

Mono-canes with a curved top handle and an adjustable length (in 1 cm increments) were used. The ends of the canes were fitted with a plastic ferrule to prevent slipping. Cane lengths were measured with subjects standing upright with both hands hanging loosely.[13] Cane lengths were measured vertically from the ground to the most prominent part of the greater trochanter (GT) or to the distal wrist crease (WC) on unaffected sides. Subjects were allowed at least 30 min to familiarize themselves with their canes.

Table 1
Baseline characteristics of the study subjects

Characteristics	
Age (years)	58.4 ± 10.6
Sex (male/female)	7/9
Height (cm)	161.6 ± 8.1
Weight (kg)	60.4 ± 13.5
Foot length (mm)	210.5 ± 52.1
Duration of brain damage (months)	40.6 ± 34.6
Brain lesion (left/right)	10/6
Injury factor (infarction/hemorrhage/etc.)	13/2/1
Modified Ashworth scale	0.9 ± 0.6
Absolute cane length (cm)	
GT	79.6 ± 4.1
WC	77.6 ± 6.6

GT, greater trochanter; WC, wrist crease.
Values are mean ± standard deviations or numbers.

A plantar pressure plate (RSscan International, Belgium, 2 m x 0.4 m x 0s.02 m, 16,384 resistive sensors, 480 Hz and 2 sensors per cm^2) was embedded a 5-m long, 1-m wide, 0.02-m thick EVA foam walkway. Because most subjects walked with a wider step width using the cane, walking parameters could not be calculated for all trials. To ensure accurate and stable data acquisition during walking, all subjects were asked to walk at least 5 times along the experimental walkway.

The RSscan system was calibrated for each subject according to the manufacturer's guidelines. After calibration, all 16 subjects were asked to walk barefoot at a comfortable speed. The following data were automatically recorded; stride length, contact areas (fore-foot, mid-foot, and rear-foot), foot axis, walking velocity, center of pressure trajectories (medial/lateral trajectory and anterior/posterior) of the affected side, and foot pressure were automatically recorded for 3 walks of approximately 3 strides in the middle of the test walkway. Mean values were then calculated.

Subsequently, walking parameters were processed using custom-made software, Footscan® 7.0 Gait 2nd Generation, RSscan International. To analyze separate regions of plantar pressure, affected side feet were divided into six regions: medial heel, lateral heel, mid-foot (medial and lateral), metatarsal heads (M_1, M_2, M_3, M_4 and M_5), hallux, and toes (T_2, T_3, T_4, and T_5).[20,21]

Statistical analysis

The normalites of quantitative data distributions were assessed using the Shapiro Wilk test ($p > 0.05$). The paired samples *t*-test was used for parametric variables, and results are expressed as means and standard deviations. The Wilcoxon signed-rank test was used for non-parametric variables, and results are expressed as medians and interquartile ranges. SPSS Ver. 21.0 (SPSS, Chicago, IL, USA) was used for the analysis, and statistical significance was accepted for p values < 0.05.

Results

Table 2 shows the walking parameters of the subjects ($n = 16$) while walking with a cane fitted to the GT or WC. The GT cane length had a wider mid-foot contact area (by 19.7%), a longer anterior/posterior center of pressure trajectory (by 9.7%), a greater toe pressure (by 26.7%), and a greater mid-foot pressure (by 14.3%) than the WC cane length. However, no significant differences were found between the two cane lengths in terms of stride length, foot axis, walking velocity.

Discussion

The main purpose of this study was to compare the effects of traditionally recommend cane lengths on walking