Purpose: The purpose of this study was to investigate the plantar pressure distribution between the affected and unaffected side in adult hemiplegia during gait with the use of a quad-cane.

Methods: Thirty-four stroke patients from 34 to 83 years of age were enrolled in this study, and in random order, all patients were asked to walk at their most comfortable speed three times along a walkway with the use of quad-cane over a period of three days. Plantar pressure distribution was measured with regard to foot contact pattern and center of pressure (CoP) trajectories during the stance phase, progressing from heel-strike to toe-off. The F-scan system was used to compare the foot pressure of the affected and unaffected sides.

Results: A significant reduction in the total contact area, the width of fore foot (FF) and hind foot (HF), and anterior/posterior (AP) CoP trajectory of the affected side was found. However, contact pressure of the hind foot on the affected side during walking increased when compared to that on the unaffected side.

Conclusion: We demonstrated that plantar pressure distribution on the affected side of adult hemiplegia patients was generally poorer than that on the unaffected side when these patients walked with cane assistance. However, the use of a quad-cane was shown to increase contact pressure of the hind foot on the affected side because weight can be borne on the affected side during heel-strike with use of the cane.

Keywords: Quad-cane, Plantar pressure, Hemiplegia

I. Introduction

Stroke is a common neurological disease and a leading cause of chronic disability worldwide. Awareness of stroke warning symptoms and risk factors as well as knowledge of available treatment options may be considered in high-risk populations. Among individuals who survive a stroke, the most frequent motor deficiency is hemiparesis or hemiplegia, with corresponding physical limitations. The important issues in rehabilitation of stroke patients include activity and participation. Activity is the nature and extent of functioning in the personnel, which includes taking care of oneself, performing a job, and daily life activities, whereas participation is an individual’s involvement in life situations related to health conditions, bodily functions and structures, and activities. After stroke, the general trend is toward decreased activity and participation.

Walking ability is important to the stroke patient because it plays a crucial role in performing activities of daily living and many tasks for independent lives. Unfortunately, the stroke patients consequently perform abnormal gait and it was well documented that 57% of patients with stroke are unable to walk without human assistance. A cane improves the hemiplegic gait by assisting the affected limb to smoothly shift the center of body mass toward the sound limb and to enhance inadequate shock absorption at heel strike and push off to maintain forward propulsion during preswing phase. Mulley described that the use of long stick in the unaffected arm encourages the patients to bear more weight through the affected side by producing a
better gait pattern. Chen et al.\textsuperscript{12} also mentioned that one-point cane provides support and a braking function for people with hemiplegic stroke.

For proper usage of cane, there are several guidelines for measuring the length of cane in a clinical setting, investigating the efficacy for people who need assistance with everyday activities.\textsuperscript{9,13} However, there is no practical documentation that compares the aspects of plantar pressure between affected and unaffected side during stance phase of gait in hemiplegic patients with the use of quad-cane. Therefore, the objective of this study was to find out the distribution of plantar pressure between affected and unaffected side in hemiplegic patients with the use of quad-cane.

II. Materials and Methods

1. Subjects
Thirty-four stroke patients with no history of major injuries such as fracture or surgery to their lower extremity were included in this study. All of the patients performed immediately comprehensive rehabilitation after stroke and the subject who can independently walk over 10 m with using of cane were participated. The participants were excluded if they had vestibular impairment that could affect elements to arouse fall down, or were able to walk without usage of cane for the equal condition to compare. The subjects were instructed about the experimental procedure and requested to sign in consent form prior to participating in the experiment. The baseline demographic characteristics of the subjects enrolled in the study are described in Table 1.

2. Experimental equipment
The quad-cane (four-point cane) as adjustable fitting length by the 1 cm was selected for what produces the wide base of support and makes hemiplegia increase postural control while walking.\textsuperscript{14,15} The F-scan system (Tekscan, USA) was used to measure foot pressure. The pressure was recorded at 50 Hz with a pressure sensitive insole consisting of a 0.15 mm thick sensor with an embedded grid work of 960 pressure-sensing cells, evenly distributed at 0.5 cm (0.2 inches) intervals. Before use, the disposable insole was trimmed to fit into the shoes.

3. Procedure
The quad-cane was constructed to the patient who stood erect with wearing comfortable indoor shoes. Each height of the cane was adjusted so that the top of the cane corresponded to the top of the greater trochanter. The lower tip of the cane was placed at a point 6 inches lateral to the little toe. The subjects wore their own indoor shoes and were fitted with the portable equipment and the insoles, which were trimmed to their shoe size and the cuff unit is attached to the lower leg with a Velcrostrap. A 9.25 m cable connects the sensor and the sensor was set to collect data at 50 Hz for 4 sec. Because temperature changes of the insole might alter the data, temperature equilibration is essential. This was ensured by a pretrial 5-minute period during which the foot was in the shoe with the sensor in place: the system was then calibrated. Using their indoor shoes bilaterally, the subjects performed 3 walks of approximately 3 steps each with the use of quad-cane for three days. Plantar pressure was recorded for 3 steps in the middle of the test walk and the mean value was calculated. After the pressure was read and saved, they were processed with custom-made software, F-Scan version 4.19F.

To assess the plantar pressure distribution with the use of cane, both sides of foot were divided in three regions: forefoot (FF), midfoot (MF) and rearfoot (RF); that is 40%, 30% and 30% of the total foot length, respectively. The measurements of parameters were grouped into 2 categories: measurements of foot contact pattern and the measurement of centre of pressure (CoP) trajectories (antero-posterior (AP) and medio-lateral (ML) trajectory).

4. Data analysis
Foot plantar pressure distributions between affected and unaffected side at the cane length of greater trochanter during walking in hemiplegic patients were analyzed with independent sample t-test of SPSS 12.0 package. The alpha level for significance was set at 0.05.

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Table 1. Demographic data of the hemiplegic patients

<table>
<thead>
<tr>
<th>Variable (M15/F19)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
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<td>11.33</td>
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<tr>
<td>Height (cm)</td>
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<tr>
<td>Weight (kg)</td>
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<tr>
<td>Foot length (mm)</td>
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<td>5.35</td>
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<tr>
<td>Onset period (months)</td>
<td>41.35</td>
<td>37.07</td>
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</table>