I. Introduction

Patients make the action slow and discordant after stroke and tend to avoid movements that they used to do. Appropriate movements based on sensory information and feedback can be diminished by hindered sensory deficit. Perception, tactile discrimination and passive movements can be difficult to make after losing proprioception and tactile sensation.\(^1\) Beside, stroke patients with the loss of proprioception of the hand lose an ability to get sensation of body parts and affect stability, perception of objects detected by the hand, hand motion control and motor function.\(^2\) Without the hand function such as movement and sensation, it is difficult to distinguish the shape, material, size and temperature of an object.\(^3\) So, movements need to get the receptors activated and feel sensation. Sensation depends on motor activities and vice versa because sensation and motor activities are closely interconnected with each other.\(^4\) Stroke patients reported that traditional rehabilitation therapy for upper limb is not shown much benefit than the lower limb.\(^5\) It can be one of the reasons that walking needs a small recovery but the upper limb function involves diverse activities like reaching, grasping, holding and coordinating. As the hemiplegic time goes on, the use of the affected upper limb tremendously decreases and gets worsen. As well, the dominant use of the less affected upper limb in fulfilling daily activities could have a negative effect upon the functional recovery of the affected upper limb.\(^6\) Hemiplegic patients benefit from constraint induced movement therapy (CIMT) on the usage and function of the affected upper limb\(^7\) or modified CIMT increases these in subjects with acute, subacute and chronic stages.\(^8\) The previous study revealed the consequences of CIMT in the function of behavior and the brain, and ways to benefit from CIMT in hemiplegic patients.

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All the methods excepting diffusion-tensor imaging (DTI) have been used to verify the mechanism of the neural system which support the clinical value of CIMT. And, the corticospinal tract (CST) is the most important structure for motor control, especially for fine motor control of the hand in humans. Neuroplasticity refers to the ability of modifying and reorganizing neurons and brain in structure and function by chaining the strength of synapses, dendrites, axons and the synaptic vesicular pool. In addition, neuroplasticity is one of the consequences of improved motor system through CIMT. In human movement, feed-forward and feedback control are anticipated and followed in initiation and ongoing movements, respectively. Anticipatory postural adjustments (APTs) is an important component for postural control. Therefore, this study aimed to verify whether modified CIMT (mCIMT) combined with APTs leads to improved corticospinal tract in hemiplegic patients.

II. Materials and methods

Nine hemiplegic patients after stroke from Daejeon Medical Care Hospital were participated in this study. The subjects were informed the purpose and methods before participating in this study. And, the subjects handed in the informed consent in advance. The inclusion criteria were as follows: 1) more than two years stroke, 2) diagnosed stroke by brain Computed tomography or Magnetic resonance imaging, 3) no more than 20° wrist flexion, 4) no more than 10° finger extension, 5) no seizures within the last 6 months, and 6) ability to understand the instruction.

A shaping which consists of Modified CIMT (mCIMT) and APAs was performed for 30 minutes per day, 5 days a week, for 4 weeks, without the less affected arm restricted from June 25th to July 24th, 2016. And, the subjects were tested with Motor Activity Log (MAL) before and after the intervention. However, three out of 8 subjects did not get DTI clear enough to analyze so that they were excluded in the result of the CST tract volume.

The shaping procedure was as follows:
1) choosing tasks customized to address the motor deficits that individual patient had, 2) if the subjects were not able to complete a movement at first, having them help to perform the movement, and 3) giving positive verbal feedback for progress in task challenge according to the patients’ improvement.

Motor Activity Log (MAL)
MAL is measured how patients use each limb by a semi-structured interview and independently rate how much and how well the patients have used the affected arm in 30 different activities of daily living in the past week. Patients and care givers use amount of use (AOU) scale which is a 6-point to rate how much they are using the affected arm, and quality of movement (QOM) scale which is a 6-point to rate how...
well they are using it.17)

Diffusion Tensor Imaging (DTI)
Diffusion tensor imaging which is a three-dimensional visualized version can visualize the integrity and architecture of white-matter tracts such as the corticospinal tract.18)

Tract volume (Tv)
Tract volume is measured by counting the number of voxels contained within a tract, and thus, reflect the total number of fibers in the tract.19)

SPSS for windows 12.0 was used for statistical analysis. Wilcoxon Signed Rank Test was used for hand function and CST volume before and after the mCIMT+APAs. A α =.05 level of significance was used for the statistical test.

III. RESULTS

The MAL AOU increased from 32.00 ± 32.04 to 65.25 ± 23.63 with a significant difference. The MAL QOM increased from 55.63 ± 21.18 to 81.88 ± 12.69 with a significant difference. (Table 2)

The score of the volume of DTI increased from 63.80 ± 40.63 to 120.80 ± 115.16. (Table 3) The volume of the corticospinal tract increased in most subjects.

IV. DISCUSSION

Most of the daily activities after stroke are influenced by the impaired upper limb function.20) CIMT based on neuroplasticity restrains the less affected arm and gets the affected upper limb moved as much as possible, which can help hemiplegic patients after stroke get over the learned nonuse. It also makes the arm function more efficient permanently resulted from the cerebral motor area extended in the brain which is in charge of upper limb function. Or, it unmasks a new motor area by doing repetition of functional exercise with the affected arm.21) In the previous study re-
ported that CIMT was applied to fifteen hemiplegic patients and the patients were not allowed to move the less affected arm. And, the patients did exercises with the affected arm for seven hours a day for eight days long, which ended up with an outstanding improvement after all. Preparatory APAs (pAPAs) which is occurring before voluntary limb movement keeps posture in stable by adapting to any perturbation. The selected motor program should go with APAs in the trunk prior to reaching for an object with the upper limb. Otherwise, the patients might use a different strategy. The previous study reported that MAL had statistically significant difference after applying CIMT to the subjects. And, the previous study showed that the subjects who were applied CIMT got to have significant differences in MAL AOU and QOM. In this study, both MAL AOU and QOM had statistically significant differences. As a result, CIMT can be a rehabilitation approach for hemiplegic patients with mild to moderately severe upper limb

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Tv: Tract volume

**Figure 1. The volume of the corticospinal tract.**
motor deficiency. The previous study revealed that transcranial magnetic stimulation (TMS) increased the number of scalp locations that made motor-evoked potentials in the affected hand. There was the ipsilateral motor map which was smaller at baseline and enlarged after CIMT and vice versa in the contralateral motor map. In this way, CIMT seemed to rebalance representations in the hand motor areas in the brain hemispheres. The previous study showed that improved motor function after CIMT improved activity in the peri-infarct zone and both hemispheres. In the previous study, all the methods (TMS, functional Magnetic Resonance Imaging (fMRI), structural MRI) except DTI have been used to verify the neural mechanisms in order to support the clinical effects of CIMT. In this study, DTI was used to enable to numerically evaluate the state or change in a neural tract and motor recovery mechanisms in patients with hemiplegia. In the previous study, evaluation of the general state, changes in neural tracts, injury severity of a lesion or lesion site was conducted and estimation of changes in the neural tracts was followed by. On the top of that, the changes of the nucleus in the brain were evaluated. In this study, even though DTI of 3 out of 8 subjects were not driven due to lack of clarity, DTI before and after mCIMT was used to verify the changes in the volume of CST of the affected hemisphere in the brain and motor function. As a result, the changes in the tract volume showed improvement in structure of the brain and upper limb function, which is resulted from the neuroplasticity. Therefore, mCIMT and APAs can improve CST through neuroplasticity and helpful in brain structure and upper limb function.

References
Modified Constraint Induced Movement Therapy Combined with Anticipatory Postural Adjustments Leads to Improved Corticospinal Tract in Hemiplegic Patients


