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Original Article

New design of home-based dynamic hand splint for hemiplegic hands: a preliminary study

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Abstract. [Purpose] Hemiplegia following a stroke can affect hand movement; therefore, reconstructing hand function is the most desired outcome for stroke patients. The purpose of this study was to explore the application of rehabilitation through the use of a dynamic hand splint and observes its effects on the muscle strength and functional activity of the affected hands. [Subjects and Methods] Chronic stroke patients who underwent a 3-month conventional rehabilitation using the dynamic hand splint were recruited . Evaluations (e.g., electromyography, grip and finger strength appraisals, and Fugl-Meyer assessment) were conducted before the test, and after the 1 and 3 month's intervention. The hemiplegic hands intermediately and after the treatment to assess improvement in hand-muscle strength and functional increase of the hand movements were evaluated. Patient response to use of the dynamic hand splint was assessed using a satisfaction scale after treatment. [Results] The results for maximal voluntary contraction of the extensor and flexor muscles and wrist and finger strength showed a statistically significant increase from the pretest to after 1 and 3 month's intervention. [Conclusion] Wearing a dynamic hand splint for home-use as a supplementary training program in addition to hospital-based rehabilitation can effectively increase the muscle strength of hemiplegic hands.
Key words: Stroke, Dynamic hand splint, Maximal voluntary contraction

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INTRODUCTION

Hemiplegia following a stroke can affect hand movement through, for example, insufficient muscle strength and inadequate muscle tone[1)]. The affected hand motion can result in a diminished ability to perform daily, functional activities[2)]. The decrease in hand motor function is a troublesome problem, obligating stroke patients to relearn functional activities[2)]. Relearning motor function can inconvenience patients for a period of 6 months or longer[3)]. Social function and psychological status are gradually lost because of the motion defect, resulting in the reduced ability of the stroke patients to participate in daily activities[4, 5)]. Therefore, the reconstruction of hand function, accompanied by a recovery of their quality of life, is a desired outcome for stroke patients.

A rehabilitation program is often designed by a physical therapist in a hospital. Repetitive-movement training can enhance the brain and neural activation links and regenerate the injured parts of the brain[6)]. Stroke patients undergo repetitive training during the rehabilitation program; however, limited therapy time often results in an ineffective rehabilitation, especially when an extension of the training program is lacking at home[7, 8)]. Hence, this study explored the application of home rehabilitation by implementing dynamic hand-splint training and assessing subsequent improvement of hand motor function.

SUBJECTS AND METHODS

This study recruited patients from the rehabilitation department of a medical center. We recruited participants exhibiting the following criteria: only assessments of Brunnstrom stage III for the ipsilateral upper extremity and distal hand movements, with scores of < 2.5 on the motor activity log, and > 24 in the mini-mental state exam. Aphasia was the exclusion criterion for patients. This study procedure was approved by the institutional review board of a hospital. The patients were volunteers and signed a consent form before the study.

In addition to conventional rehabilitation, the participants received a customized dynamic hand splint (Fig. 1) for home rehabilitation exercise which was scheduled for 30 minutes per session, 5 times a week, and continued for 3 consecutive months. The dynamic hand splint helped the participants to practice finger extensions by using three progressively stiffer elastic-spring strength levels. The elastic force could be decreased to allow the participants to extend their hands more easily. The adjustment level of the dynamic hand splint's spring and the ability of the participants to engage in

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advanced training were determined by therapists according to the muscle tone and hand motion of the participants.

Evaluations were performed before the test and after 1 and 3 month's intervention. An assessment of maximal voluntary contraction by electromyography (EMG), grip and finger strength appraisals, and the Fugl-Meyer assessment, were performed to confirm improved hand-muscle strength and to evaluate the function of hemiplegic hand movements after the dynamic hand splint had been used at home. Using the paired-sample t test, the collected data were analyzed to determine whether differences between before the intervention and after 1 and 3 months were significant. The study data were analyzed using SPSS17.0 (SPSS Inc., Chicago, IL, USA).

We also used patient a satisfaction scale to assess the effect of using this dynamic hand splint. The scale included the following three fields: satisfaction with the home-practice program, satisfaction with the therapist's training guidance, and expectations of recovery.

RESULTS

Ten chronic stroke patients with hemiplegia, (three left-handed and seven right-handed), completed the study. The average age of the participants was 50.21 ± 13.27 years, with the onset time of the stroke being 3.17 ± 0.98 years earlier. EMG of extensor and flexor muscles, based on maximum muscle contraction, as well as a wrist and finger strength test exhibited statistically significant increases between the pretest and the evaluations after 1 and 3 month's intervention ($p < 0.05$). The Fugl-Meyer assessment scores has also increased compared to the pretest to after 1 and 3 month's intervention ($p > 0.05$) (Table 1). The patient satisfaction scale showed scores ranging from 84 to 92 in the responses to the questions about the convenience of the splint, recovery of the hemiplegic hand, therapists' guidance and expectations of recovery.

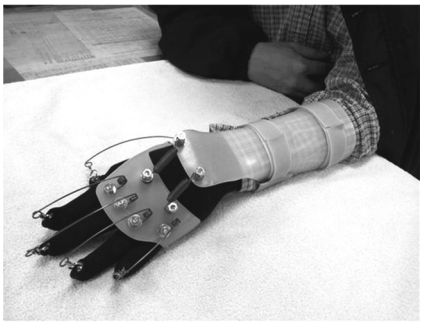

Fig. 1. Customized dynamic hand splint

DISCUSSION

Stroke might result in the inability to move one or more limbs on one side of the body, and also affects patients' ability to participate in activities of daily life[9]. Consequently, recovery of hand function is one of the main goals of a rehabilitation program. However, stroke patients have dysfunction in multiple areas, and hospital rehabilitation time is limited. Hospital-based rehabilitation training is insufficient to raise the efficiency of hand-function[10]. In this study, we designed a dynamic hand splint for home-based training as an extension of the training program at a hospital. Our aim was to determine whether improvements of muscle strength and movement would occur. This study found that stroke patients had a high level of satisfaction with the home-use dynamic hand splint. The study also demonstrated that patients exhibited a favorable acceptance of the assistive device.

The EMG recordings indicated significant improvements in hand muscle strength after 1 month, and 3 months of the intervention. We consider that the elastic force of the dynamic hand splint assisted the affected hand in opening and grasping operations. The rehabilitation program improved grip and finger strength. It was previously reported that functional grasping by the hand assisted by a dynamic hand splint activated the recruitment of motor units[11, 12]. However, in the present study, no significant improvements were seen in the Fugl-Meyer assessments after 1 and 3 months of the intervention. This result is similar to the results of two previous studies[13, 14]. The Fugl-Meyer assessment is a functional evaluation of stroke patients. A previous study reported a strong correlation between the Fugl-Meyer assessment and functional activity[15]. Our results show that functional activity did not manifest a significant improvement following use of the dynamic hand splint. We conclude that increased muscle strength is insufficient for achieving motor recovery. The present study had the following limitations: a small sample size, a lack of long-term follow-up, and the absence of a control group. A larger sample or a randomized control trial is suggested for future investigations of the effects of the dynamic hand splint. As an extension of a conventional rehabilitation program, wearing a home-use

Table 1. The assessment results of the 10 stroke patients

	Before	1 month	3 month
Fugl-Meyer assessment	38.2 ± 2.32	38.8 ± 5.45	39.3 ± 6.21
Maximal voluntary contraction			
Wrist extensor muscle (mV)	48.4 ± 9.89	55.2 ± 8.12*	57.1 ± 9.88**
Wrist flexor muscle (mV)	65.3 ± 13.2	78.6 ± 10.3*	80.4 ± 9.32**
Grip strength (Kg)	3.24 ± 0.79	4.78 ± 1.01*	4.97 ± 0.85**
Finger strength (Kg)	2.32 ± 0.89	3.56 ± 0.93*	3.86 ± 0.81**

*$p < 0.05$, before vs. 1 month; **$p < 0.05$, before vs. 3 months

dynamic hand splint can increase the muscle strength of the hemiplegic hand; however, whether the splint's performance can accomplish the recovery of hand function requires more discussion. Wearing a home-use dynamic hand splint as a training program to supplement hospital-based rehabilitation effectively increased the hand-muscle strength of the hemiplegic side and should be considered for routine inclusion in rehabilitation programs.

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