

Effect of Hand-free “Chin Tuck against Resistance (CTAR)” Exercise on Hyoid Bone Movement and the Degree of Aspiration in Stroke Patients with Dysphagia: A Report of 2 Cases

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This study recruited two men with dysphagia after stroke, aged 57 and 62 years. They had difficulty using both hands properly due to paralysis of the left upper extremity and rheumatoid arthritis of the right hand in patient 1 and paralysis of both upper extremities in patient 2. This study examined the effects of 4 weeks of hand-free chin-tuck-resistance exercise on the hyoid movement and aspiration. The exercises involved isotonic and isometric parts. In isometric CTAR, the patients were asked to chin tuck against the device 3 times for 60 s each with no repetition. In isotonic CTAR, the patient performed 30 consecutive repetitions by strongly pressing against the resistance device and then releasing it. Based on a video fluoroscopic swallowing study, the degree of aspiration was measured using the Penetration-Aspiration Scale (PAS) and two-dimensional motion analysis of the hyoid bone. Post-intervention, the hyoid movements in both patients improved by 0.16 and 0.22 cm (anterior movement), and 0.26 and 0.28 cm (superior movement), and the PAS scores decreased by 2 and 2 points, respectively. This study confirms that hands-free chin-tuck resistance exercise is applicable and helpful for improving the hyoid movement and reducing aspiration in patients with dysphagia after stroke. Therefore, this exercise can be introduced as an intervention for improving the swallowing function in patients with dysphagia who have difficulty using both hands. (JKDS 2018;8: 121-125)

Keywords: Dysphagia, Hand-free chin-tuck-resistance exercise, Stroke, Swallowing, Suprahyoid muscle

INTRODUCTION

Swallowing is broadly divided into oral, pharyngeal,

and esophageal phases. Various problems that arise in this series of processes are collectively known as dysphagia. Dysphagia is a common occurrence in

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neurological diseases and leads to various complications, such as dehydration, aspiration pneumonia and malnutrition¹.

Since these complications adversely affect rehabilitation, proper initial swallowing therapy is important. Neurological diseases cause weakness of muscles associated with swallowing, which can affect the normal swallowing mechanism. In particular, weakening of the suprahyoid muscles in the anterior neck region is known to affect opening of the upper esophageal sphincter and lead to aspiration, since safe swallowing requires sufficient contraction of the suprahyoid muscles².

Therefore, therapeutic exercises to strengthen the suprahyoid muscles are important for patients with aspiration or a high risk of aspiration. A variety of exercise methods to strengthen the suprahyoid muscles are currently in clinical use. The Shaker exercise involves movements of repeated lifting of the head from the floor against gravity in the supine position³.

The goal is to enable safer swallowing through reinforcement of suprahyoid muscles. Previous studies have reported that the Shaker exercise is effective in increasing hyoid motion, decreasing aspiration, and opening the upper esophageal sphincter^{4,5}. Nonetheless, the Shaker exercise is known to cause problems such as excessive neck and abdominal effort, myalgia, and muscle fatigue. In other words, it is relatively inefficient in terms of the desired effect as compared to the effort involved. To overcome this problem, chin-tuck-resistance and chin to chest exercises were introduced⁶. These exercises serve the same purpose as the Shaker exercise, but can be performed while sitting. It can also activate suprahyoid muscles nearly similar to the Shaker exercise. However, the sternocleidomastoid muscles are stimulated to a lesser extent. In other words, the target muscle can be trained more selectively and effectively than with use of the Shaker exercise, and fatigue of the sternocleidomastoid muscles is less, thus increasing performance efficiency. However, since these exercises can be carried out by hand, using a tool that provides resistance such as a resilient ball or a resistance bar,

at least one hand is required to have proper function and strength. Therefore, patients who are unable to functionally use both hands for various reasons, such as limb paralysis, spinal cord injuries, traumatic or acquired brain injuries, are limited by their conditions. The purpose of this study was to investigate the effect of chin-tuck-resistance exercise using hand-free resistance bar on hyoid movement and aspiration in patients with dysphagia, who had difficulty in functional use of both hands.

CASE REPORT

This study recruited two patients with dysphagia who had difficulty in functional use of both hands. The criteria for selection were as follows: 1) patients diagnosed with brain damage 2) patients with functional limitation of both upper extremities 3) patients with a diagnosis of swallowing disorder 4) patients with brain injury in the past 3 months 5) patients who could maintain a sitting position without a guardian 6) patients who do not have a cognitive problem. Exclusion criteria were as follows: 1) those who had a tracheostomy 2) those who had pain or discomfort in the neck 3) those who wore a cervical collar. The characteristics of the subjects were as follows.

Patient 1 was a 57-year-old man diagnosed as having dysphagia after stroke in 2017. Right middle cerebral artery infarction resulted in left upper extremity muscle weakness, decreased functional movement and swallowing disorder. VFSS results showed no problems for semisolid and solid food, but aspiration when on a liquid diet and Penetration-Aspiration Scale (PAS) score was 6 points. He had good muscle strength in the right upper limb, but limited grip and use of the fingers due to rheumatoid arthritis, diagnosed five years ago. His MBI score was 75 points and the MMSE-K score was 17 points.

Patient 2 was a 62-year-old man with left hemiplegia due to right middle cerebral artery (MCA) infarction in 2012. There were no symptoms related to swallowing at the time. However, after diagnosis of MCA hemorrhage due to aneurysm rupture of the left middle

cerebral artery in 2018, weakness of the right upper limb was seen. The muscle strength of both upper extremities showed poor to fair grade. The main problem with VFSS results was reduction of hyoid movement and aspiration. In particular, the PAS score was evaluated at 6 points on liquid type. The MBI score was 65 points and the MMSE-K score was 18 points.

We performed the hand-free "chin-tuck against resistance" (CTAR) exercise by using a Phagioflex-HF (Alternative Speech and Swallowing Solutions, Inc., FL, USA) in 2 patients with dysphagia after stroke. Unlike conventional CTAR tools, this tool was designed to activate the suprahyoid muscles only through chin-tuck motion without using both upper limbs. The exercise was performed with the patient sitting in a chair, and the resilience resistance bar firmly fixed to the desk. CTAR was performed by placing the distal end of the resistance bar on the desk and placing the opposite end under the patient's chin. (Fig. 1) The exercise involved isotonic and isometric parts, in the same manner as seen in previous studies. In isometric CTAR, the patients were asked to chin tuck against the device 3 times for 60 s each, with no repetition. In isotonic CTAR, the patient performed 30 consecutive repetitions by strongly pressing against the resistance device and releasing it again. To perform the CTAR correctly, the therapist explained and demonstrated the exercise methods to all patients

before the intervention. We emphasized the correct chin tuck posture to ensure the patients do not flex their heads against the devices. We also instructed them to press as strongly as possible for greater activation of the suprahyoid muscles. Two patients received the same conventional dysphagia treatment (CDT), such as orofacial muscle exercises, thermal tactile stimulation, and therapeutic or compensatory maneuvers. An experienced occupational therapist performed the CDT in all patients for 30 min/day, 5 days a week, for 4 weeks.

To measure outcomes, Image J program (National Institutes of Health, Bethesda, MD, USA) was used for movement analysis of the hyoid bone, and PAS was used to quantify the degree of penetration-aspiration. Hyoid bone movement was analyzed using similar method as in a previous study⁵. The swallowing process was captured using a frame during VFSS. Two picture frames of VFSS were used for the analysis: 1) rest position of the hyoid and 2) maximal excursion of the hyoid. The application of vertical C2-C4 axis utilized an image rotation technique. A straight line was drawn between the most antero-inferior points, C2 and C4, and then the images were rotated to the true vertical 90°. The antero-inferior corner of C4 was identified on each image and used as an "anchor point", which represents a stable point (resting position) of the hyoid before swallowing from the distance of moving hyoid. Hyoid displacement represents the distance



Fig. 1. Hand-free chin-tuck-resistance exercise.

from the resting position to the maximal excursion position during swallowing, the most supero-anterior point of the hyoid indicates maximum displacement after swallowing.

According to the results in patient 1, anterior movement of the hyoid bone improved from 1.45 cm to 1.61 cm. Superior movement improved from 1.55 cm to 1.81 cm. On PAS evaluation, the score decreased from 6 points to 4 points for 5 ml liquid type. According to the results in patient 2, the anterior movement of the hyoid bone improved from 1.54 cm to 1.76 cm. Superior movement improved from 1.63 cm to 1.91 cm. On PAS evaluation, the score decreased from 6 points to 4 points for 5 ml liquid type. After completing the intervention, no side effects such as neck pain or discomfort were reported.(Table 1)

DISCUSSION

This study investigated the effect of hand-free CTAR on hyoid movement and aspiration in patients with dysphagia after stroke. On analysis of the hyoid movement, anterior movement improved by about 1.5-2.5 mm and superior movement improved by about 2-3 mm in both patients. Movement of the hyoid bone is one of the most important factors in normal swallowing, and the hyoid bone moves due to the contraction of the suprahyoid muscles. In particular, the geniohyoid muscle is responsible for anterior movement of the hyoid bone, and the mylohyoid muscle is responsible for superior movement². Previous

studies have demonstrated that CTAR is effective in the activation of suprahyoid muscles in patients with dysphagia after stroke. CTAR was reported to be similar to the Shaker exercise but elicited more muscle activation⁷. Muscle activation involves a lot of recruitment of the motor units and also has the potential to affect muscle volume and muscle strength increase. In this study, hand-free CTAR was also expected to increase muscle strength by inducing continuous muscular contraction of the target muscle with almost the same resistance exercises as used in previous studies. During swallowing, the suprahyoid muscles directly affect hyoid movement and consequently affect airway protection through epiglottis rotation. Movement of the hyoid bone is closely related to the airway protection mechanism. Therefore, this study evaluated the degree of aspiration of two patients using PAS assessment. Results indicate that patient 1 showed a reduction in PAS score from 6 to 4 points for liquid type and patient 2 from 6 points to 4 points. Patient 1 had severe aspiration symptoms before intervention but only penetration was observed after intervention. Previous studies have reported improvements in pharyngeal swallowing function, including reduction of aspiration, in patients with dysphagia after stroke⁶, similar to the results of this study. Therefore, sufficient movement of the hyoid bone is essential for the reduction of aspiration, and hand-free CTAR is considered a resistance exercise effective for improvement of hyoid movement and decrease of aspiration. This case study differs from previous studies in that CTAR

Table 1. Changes in parameters before and after treatment.

	Patient 1			Patient 2		
	Before treatment	After treatment	Improvement rate (%)	Before treatment	After treatment	Improvement rate (%)
Anterior movement of the hyoid bone (cm)	1.45	1.61	11.0	1.54	1.76	14.2
Superior movement of the hyoid bone (cm)	1.55	1.81	16.7	1.63	1.91	17.1
PAS	6	4		6	4	

PAS: penetration-aspiration scale.

was effectively applied without using hands. Hand-free CTAR is another remedial method applicable in patients with dysphagia who are unable to use both hands properly for some reason, such as limb paralysis, spinal cord injury, and hemiplegia with arthritis.

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