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Efficacy of modified chin tuck against resistance exercise using hand-free device for dysphagia in stroke survivors: A randomised controlled trial

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Abstract

Background: Chin tuck against resistance exercise was recently reported as a novel method for improving the swallowing function of patients with post-stroke dysphagia. However, as this exercise involves holding and fixing the device using the hand, physically weak patients may find it difficult to perform it.

Objectives: This study aimed to investigate the effect of modified chin tuck against resistance (mCTAR) exercise on patients with post-stroke dysphagia.

Methods: In total, 30 patients with dysphagia were recruited in this study. They were randomly assigned to either the experimental or control group. The experimental group performed mCTAR exercise and received traditional dysphagia treatment, whereas the control group received only traditional dysphagia treatment. mCTAR exercise involved isometric and isotonic exercises. Aspiration and oral diet were evaluated using penetration-aspiration scale (PAS) and functional oral intake scale (FOIS), respectively. Moreover, the rate of nasogastric tube removal was analysed.

Results: Compared with the control group, the experimental group showed statistically significant improvement in PAS and FOIS ($P < 0.001$, both). The rates of nasogastric tube removal were 25% and 15% in the experimental and control groups, respectively.

Conclusion: This study demonstrated that mCTAR exercise can reduce aspiration and improve dietary levels in patients with post-stroke dysphagia. Therefore, mCTAR exercise is expected to be beneficial for physically vulnerable patients with dysphagia who have limited hand strength and range of motion.

KEYWORDS

aspiration, chin tuck against resistance, dietary, dysphagia, stroke

1 | BACKGROUND

Dysphagia is the medical term used to describe swallowing difficulties. The most frequent concerns in the pharyngeal phase include post-swallow residue, wall coating and aspiration of ingested material into the airway. This may cause complications such as dehydration, malnutrition and aspiration pneumonia and, in severe cases, death.[1] Therefore, performing appropriate therapeutic exercise that prevents complications and improves swallowing function is extremely important.

Treatment for dysphagia is largely divided into compensatory and therapeutic methods. Compensatory methods help swallow food in

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a safer manner through postural change, dietary modifications, etc; however, the effects of these methods are temporary.[2] Therapeutic methods aim to improve swallowing ability through sensory stimulation and strengthening of muscles.[3] Although these methods require more time to improve function than compensatory methods do, they have long-lasting effects.[4]

The head lift exercise (HLE) is a therapeutic method that strengthens the suprahyoid muscles located below the chin. It is often called the Shaker exercise, and it stimulates the suprahyoid muscles by repeating or maintaining the head lifted from the floor in a supine position.[1] Suprahyoid muscles play a very important role in normal swallowing. The contraction of these muscles in the pharyngeal phase pulls the hyoid bone forward and upward, resulting in direct and indirect mechanisms of airway protection and opening of the upper oesophageal sphincter.[5,6] Although this exercise is performed in the supine position, it requires excessive physical effort, which may be difficult to execute for patients with neurological diseases.[7]

Recent studies have introduced a modified therapeutic exercise that complements the limitations of HLE. Mishra et al[8] have shown how to adjust the back angle to alleviate physical effort while performing HLE. As a result, muscle activity in the suprahyoid muscles is reported to be similar to that at 0° even when the backrest angle is adjusted. Another study reported a method of suprahyoid muscle training using a resilient object (eg ball and synthetic resin) in a sitting position, followed by the chin tuck position.[9,10] There is no relative spatial limitation, as the CTAR exercise can be performed while being seated. Moreover, it has the advantages of less physical effort and decreased risk of muscle fatigue. However, this exercise requires strength and range of motion of the hand in order to hold the elastic object in place and maintain proper posture. Therefore, this study investigated the effect of modified CTAR (mCTAR) exercise on patients with post-stroke dysphagia.

2 | METHODS

2.1 | Participants

In total, 30 patients with dysphagia were recruited in this study. The inclusion criteria were as follows: (1) diagnosed as having had a stroke within 6 months post-onset; (2) dysphagia was confirmed by a videofluoroscopic swallowing study (VFSS); (3) liquid aspiration or penetration on VFSS; (4) those with a nasogastric (NG) tube; (5) able to communicate properly, those without any cognitive deficit (>22 points in the Mini-Mental Status Examination); and (6) cortex damage only. The exclusion criteria were (1) secondary stroke; (2) gastrostomy tube; (3) those who had undergone tracheostomy; (4) those with neck or shoulder pain; and (5) those with cervical herniated nucleus, cervical spine orthosis or brainstem stroke (eg lateral medullary infarction). Written informed consent was obtained from all subjects before the study. Ethical approval for this study was obtained from Inje University Institutional Review Board (INJE 2018-07-024).

2.2 | Sample size estimation

Sample size was calculated using G-power 3.1 software (University of Dusseldorf, Dusseldorf, Germany). The power and alpha levels were set at 0.60 and 0.05, respectively, and the effective size was set at 0.8. According to a prior analysis, each group required at least 12 subjects. Therefore, a total of 24 subjects were required. However, we recruited 30 subjects considering the possibility of dropouts.

2.3 | Intervention

In total, 30 patients were randomly allocated to either the experimental or the control group by blocked randomisation. The allocation sequence was generated via a Web-based random allocation system (http://www.randomizer.org/).

The experimental group performed the mCTAR exercise using a PhagiaFLEX-HF (Alternative Speech and Swallowing Solutions, Inc). The device is made of polypropylene and has a thickness of about 8 mm and a length of about 20 cm. A total of four curved surfaces are formed, and each curved surface is divided into a fixed portion, supporting portion and chin surface (Figure 1).

The method of performing the mCTAR exercise was as follows. First, the subject sat in a comfortable chair. Then, the fixed part of the device was secured to the desk surface. Subsequently, the height of the desk was adjusted in order to firmly attach the chin

FIGURE 1 Modified chin tuck against resistance exercise

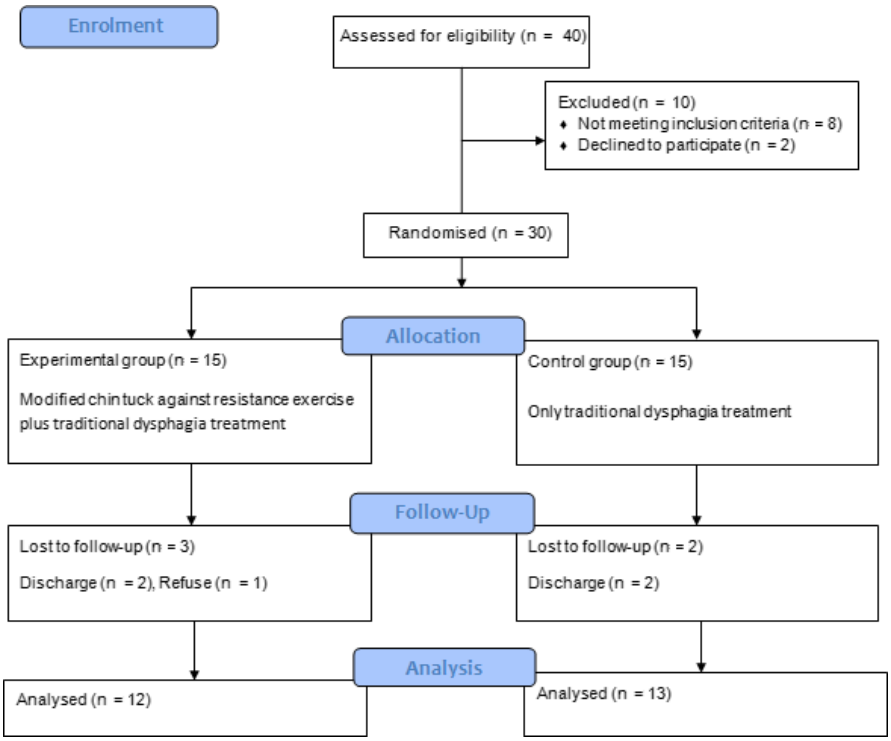

FIGURE 2 CONSORT diagram of study

surface under the chin. The exercise was performed in this posture, and it was further divided into isotonic and isometric exercise. The isometric exercise involved holding the chin down for 10 seconds against the resistance (10 seconds, thrice). Isotonic exercise was repeated 30 times in the chin-down position against resistance.

Both groups received traditional dysphagia treatment (TDT) by skilled occupational therapists (30 min/d). TDT included oral facial massage, thermal-tactile stimulation and various compensatory trainings. The intervention was delivered 5 days a week, for 6 weeks.

2.4 | Outcome measurement

The primary outcome measure was the penetration-aspiration scale (PAS). The PAS is an 8-point observational scale used to measure the severity of airway aspiration; higher levels of airway aspiration indicate a greater aspiration severity.[11]

The secondary outcome measure was the functional oral intake scale (FOIS). The FOIS consists of a 7-point scale, where level 1 indicates complete impairment of oral intake, and level 7 implies complete oral intake regardless of food consistency or type.[12]

2.5 | Statistical analysis

All statistical analyses were performed using SPSS version 15.0 (IBM Corporation). Descriptive statistics are presented as means with standard deviations. The Shapiro-Wilk test was used to check the normality of the outcome variables. To evaluate the intervention effects, Wilcoxon signed-rank and Mann-Whitney test were used to compare the pre- and post-intervention measures in each group and to compare the intergroup changes in outcome measures, respectively. The statistical significance level was set at $P < 0.05$.

In addition, effect sizes (Cohen's d) were calculated by dividing the difference of the standardised means of the two groups by their standard deviations. Effect sizes (Cohen's d) of 0.2, 0.5 and 0.8 represented small, moderate and large effects, respectively.

3 | RESULTS

3.1 | Participants

In this study, 30 subjects were recruited, 5 of which dropped out. Thus, data from a total of 25 patients were analysed. The flow chart of the study is shown in Figure 2, and the general characteristics of the participants are shown in Table 1.

3.2 | PAS assessment

The experimental group showed a statistically significant improvement in PAS assessment ($P < 0.001$). On the contrary, no statistically significant difference was observed in the control group ($P = 0.089$). After intervention, a statistically significant difference was observed between the two groups ($P < 0.001$) (Table 2). The effect size showed PAS assessment (1.3).

3.3 | FOIS assessment

The experimental group showed a statistically significant improvement in FOIS assessment ($P < 0.001$), whereas there was no statistically significant difference in the control group ($P = 0.068$). After

TABLE 1 Characteristics of participants

Characteristics	Experimental group (n = 12)	Control group (n = 13)
Age (year), mean ± SD	63.5 ± 5.5	65.2 ± 6.2
Gender (male/female)	6/6	6/7
Type of stroke (haemorrhage/infarction)	5/7	7/6
Side of stroke (right/left)	5/7	4/9
Facial palsy	1	1
Dysarthria	1	0

Abbreviation: SD, standard deviation.

intervention, a statistically significant difference was observed between the two groups ($P < 0.001$) (Table 2). The effect size showed FOIS assessment (1.1).

3.4 | NG tube removal ratio

After intervention, the NG tubes of 3 out of 12 patients (25%) in the experimental group and 2 out of 13 patients (15%) in the control group were removed.

4 | DISCUSSION

mCTAR exercise is applied as a therapeutic exercise to strengthen the suprahyoid muscles. However, it is slightly different from the previous CTAR exercise. Patients with neurological disorders, such as stroke, are physically vulnerable owing to various causes. Therefore, this study aimed to introduce a therapeutic exercise that does not require physical factors, such as upper extremity muscle strength or range of motion, and to investigate the effects of mCTAR exercise on the reduction in aspiration and dietary stages in patients with post-stroke dysphagia.

The degree of aspiration was assessed using PAS assessment, based on VFSS. Compared with the control group, the experimental group showed a significant decrease in aspiration. Previous studies have demonstrated that CTAR exercise is an effective method to activate the suprahyoid muscles, using surface electromyography.[10,13] The activation of more muscle fibres is likely to generate more power by recruiting more motor units. Therefore, repetitive training is a potential source of induction of the suprahyoid muscles.

In the pharyngeal phase, contraction of the suprahyoid muscles induces movement of the hyoid bone and also contributes to airway protection through tilting of the epiglottis,[4] which, in turn, is closely related to the contractility of the suprahyoid muscles. Park et al[14] reported that CTAR exercise reduced aspiration in patients with post-stroke dysphagia, explained by the resistance training of suprahyoid muscles through the CTAR exercise, which is also consistent with the present findings. Resistance training is known to induce mechanical changes, such as muscle volume gain and muscle strength, by providing loading to the target muscle. Oh[15] also reported an increase in the volume of the suprahyoid muscles as a result of resistance training in swallowing muscles, suggesting that the suprahyoid muscles contained in the skeletal muscle also respond well to resistance training. This suggests that resistance training through the mCTAR exercise reduces aspiration because of strength training of the suprahyoid muscles.

This study evaluated NG tube clearance and oral diet. At the end of the intervention period, 3 out of 12 patients in the experimental group and 2 out of 13 patients in the control group had their NG tubes removed. In addition, FOIS evaluation score showed a significant improvement in the experimental group compared with the control group, which indicated that patients were able to safely swallow food items of various consistencies and viscosities. In other words, mCTAR exercise seems to have a positive effect on NG tube removal and resumption of oral diet.

This study demonstrated that mCTAR exercise is effective in improving the swallowing function in patients with post-stroke dysphagia. Nonetheless, some inconveniences about applicability of mCTAR exercise were noted. For example, the height of the desk should be adjusted to ensure proper positioning of the device. Also, optimal thickness of the desk is important to ensure secure fixation of the tool in order to provide proper resistance. Hence, exercise devices of various sizes to suit the end users are required.

This study has some limitations. First, the results of this study could not be generalised owing to its limited sample size. Second, the

TABLE 2 Changes in parameters before and after treatment

	Experimental group				Control group				Between group P-values
	Before	After	Mean change	P-value	Before	After	Mean change	P-value	
PAS	4.60 ± 0.82	3.07 ± 0.59	1.53 ± 0.74	<0.001*	4.93 ± 0.88	4.47 ± 0.91	0.53 ± 0.99	0.089	<0.001†
FOIS	3.40 ± 1.05	5.07 ± 0.88	1.67 ± 0.72	<0.001*	3.19 ± 0.68	3.67 ± 1.23	0.47 ± 0.91	0.068	<0.001†
NG tube removal	12	9	3 (25%)	-	13	11	2 (15%)		-

Note: Mean ± standard deviation.
Abbreviations: PAS, penetration-aspiration scale; FOIS, functional oral intake scale; NG tube, nasogastric tube.
*$P < 0.05$ by Wilcoxon test.
†$P < 0.05$ by Mann-Whitney U test.

mCTAR device used in this study could not be adjusted for the intensity of resistance, making it difficult to conduct objective resistance training. Third, the effects of HLE or conventional CTAR exercise were not compared. Fourth, as mCTAR and TDT were performed simultaneously, the results could not be attributed to mCTAR exercise alone. Further studies are warranted to overcome these limitations.

5 | CONCLUSION

This study demonstrated that the mCTAR exercise is an effective method for reducing aspiration and improving dietary levels of patients with post-stroke dysphagia. Therefore, mCTAR exercise is expected to be beneficial for physically vulnerable patients with dysphagia who have limited hand strength and range of motion.

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CONFLICT OF INTEREST

None to report.

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