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Effect of Kinesiology Taping on Hyolaryngeal Complex Movement in Stroke Patient with Dysphagia

Background: Kinesiology taping (KT) is a method that helps immediately increase muscle activation, strength and joint stability by being attached to various skeletal muscles and structures of the body.
Objectives: To investigate the effect of KT applied below the hyolaryngeal complex on the movement of the hyolaryngeal complex during swallowing in patients with dysphagia after stroke.
Design: One-group, pre-post design.
Methods: Twenty individuals with dysphagia after stroke participated in this study. KT was applied to the sternum and both clavicles from the hyolaryngeal complex. We analyzed the motion of the hyolaryngeal complex during swallowing with and placebo KT and KT using the Image-J software with videofluoroscopic swallowing study. In addition, a 0-to-10 numerical rating self-report scale was used to check the required effort and resistance felt during swallowing.
Results: KT condition showed that the anterior and superior movement of the hyoid bone during swallowing was significantly lower than placebo KT (P<.05, all). Also, KT condition showed that the anterior and superior movement of the larynx during swallowing was significantly lower than placebo KT (P<.05, all). In result of statistical comparison between KT group and placebo KT group, the KT group showed significantly higher self-report scale score than the placebo KT group in terms of two category; the required effort and resistance felt (P<.05, all).
Conclusion: This study demonstrated that KT applied below the hyolaryngeal complex inhibits the anterior and superior movement of hyoid bone and larynx during swallowing of patients with dysphagia after stroke.

Keywords: *Dysphagia; Hyolaryngeal complex; Stroke; Kinesiology taping*

Junyong Hong, RT[a], Donghwan Oh, OT, Prof., PhD[b], Jisu Park, OT, Prof., PhD[c], Youngjin Jung, Prof., PhD[d]

[a]Department of Multidisciplinary Radiological Science, Dongseo University, Busan, Republic of Korea; [b]Department of Occuptional Therapy, Kyungdong University, Wonju, Republic of Korea; [c]Advanced Human Resource Development Project Group for Health Care in Aging Friendly Industry, Dongseo University, Busan, Republic of Korea; [d]Department of Radiological Science, Dongseo University, Busan, Republic of Korea

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Address for correspondence
Youngjin Jung, Prof., PhD
Department of Radiological Science, Dongseo University, 47, Jurye-ro, Sasang-gu, Busan, Republic of Korea
Tel: 82-10-8758-6134
E-mail: microbme@outlook.com

INTRODUCTION

Swallowing muscles located in the pharyngeal phase are classified into suprahyoid muscles and infrahyoid muscles on the basis of the hyoid bone.[1] The suprahyoid muscles, composed of the geniohyoid, mylohyoid, and digastric muscles, are located between the mandible and the hyoid bone.[2] Contraction of these muscles contributes to the normal swallowing mechanism by pulling the hyolaryngeal complex, composed of the hyoid bone and the larynx, upwards during the swallowing process.[3] Therefore, it is important to increase the movement of the hyolaryngeal complex during swallowing by reinforcing the action of the suprahyoid muscles in dysphagia rehabilitation. Previous studies have applied a variety of therapeutic methods such as electrical stimulation, head lift exercise, jaw opening exercise and effortful swallowing to enhance the suprahyoid muscles and have demonstrated improved swallowing with increased movement of the hyolaryngeal complex.[4-6]

On the other hand, Park et al.[7] provided electrical stimulation to the infrahyoid muscles in contrast to most previous studies. The contraction of the infrahyoid muscles produces a mechanism of pulling the hyolaryngeal complex downward,[8] and patients require more effort for normal swallowing.[7] As a result, the suprahyoid muscles are loaded with a lot of resistance and can be applied as resistance training.

Other studies have also demonstrated the increased movement of the hyolaryngeal complex during swallowing by applying effortful swallowing for several weeks after intentionally lowering the hyolaryngeal complex by applying electrical stimulation to infrahyoid muscles in patients with dysphagia.[1,9] Therefore, resistance exercise targeting the infrahyoid muscle is effective as a therapeutic exercise method to improve swallowing function. Previous studies, however, did not report pure resistance training of suprahyoid muscles because the movement of the hyolaryngeal complex was inhibited via electrical stimulation.[1,7,9,10] In addition, there were various problems such as muscle fatigue, pain, and discomfort because it was generally applied to the maximum intensity that the patient can withstand in order to induce contraction of the infrahyoid muscle through electrical stimulation. Therefore, an alternative method that can be applied as resistance training in dysphagia rehabilitation is needed; this method should be more adaptable, easier to perform, and without pain or a tingling sensation compared to the electrical stimulation method.

Kinesiology taping (KT) is a method that helps immediately increase muscle activation, strength and joint stability by attaching to various skeletal muscles and structures of the body.[11–13] An additional function of KT is to fix or suppress the movement of the body structure using physically external force. In addition, as KT does not provide a strong stimulus to skin receptors, it is not only painless but also noninvasive and easy to perform.[14] Recently, Park et al. proved the immediate activation of suprahyoid muscle as a result of applying resistant training using KT, which suggested the possibility of new dysphagia treatment. However, the basis for resistant training using KT is still unclear. Because the previous study only measured muscle activation using sEMG, no kinematic studies of swallowing related structures were performed. Also, since it was applied to healthy adults, the effect on stroke patients with dysphagia is unknown.[15]

In this study, we investigated the effect of KT as a method to suppress the movement of the hyolaryngeal complex during swallowing in patients with dysphagia following stroke.

SUBJECTS AND METHODS

Participants

This study enrolled 20 patients diagnosed with dysphagia after stroke. The inclusion criteria were as follows: Major problems in the pharyngeal phase, within 3 months of onset of stroke, ability to communicate properly, no cognitive problems with Mini Mental State Examination–Korean version 24 score or above, ability to voluntarily swallow, consumption of an oral diet, and decreased hyoid bone movement during swallowing in videofluoroscopic swallowing study (VFSS). The exclusion criteria were as follows: tape allergy on the anterior neck, presence of nasogastric tube, or a tracheotomy. Finally, 23 patients who met the inclusion and exclusion criteria were included in the study.

Ethics

The objectives and requirements of the study were explained to all participants, who voluntarily signed an informed consent form. Ethical approval was obtained from the Seoul Medical Center Institutional Review Board prior to study commencement (2018–07–023–008).

Methods

This study was conducted using a one–group design, with participants examined with KT and with a placebo KT. All subjects underwent a VFSS in the KT and placebo–KT conditions, and the order was randomly selected using an opaque envelope by the researcher, who has no conflict of interest with the present study (Figure 1). The evaluation was performed by a blinded rehabilitation physician and an occupational therapist.

Videofluoroscopic swallowing study (VFSS) is a radiographic evaluation of the swallowing processes and anatomical structures (e.g., hyoid bone, larynx). VFSS is an objective, standardised test that is the most commonly used method for evaluating dysphagia. Participants sat in an upright position, at a distance of 1.5 m from the X–ray tube, with the head stabilised. Participants were asked to forcefully swallow 2 mL of 35% barium (w/v). Videofluoroscopic images taken in the lateral view were captured directly using a digital picture archiving and communication system. The capture rate was 30 fps, and the frame size was 1021 x 1021 pixels.

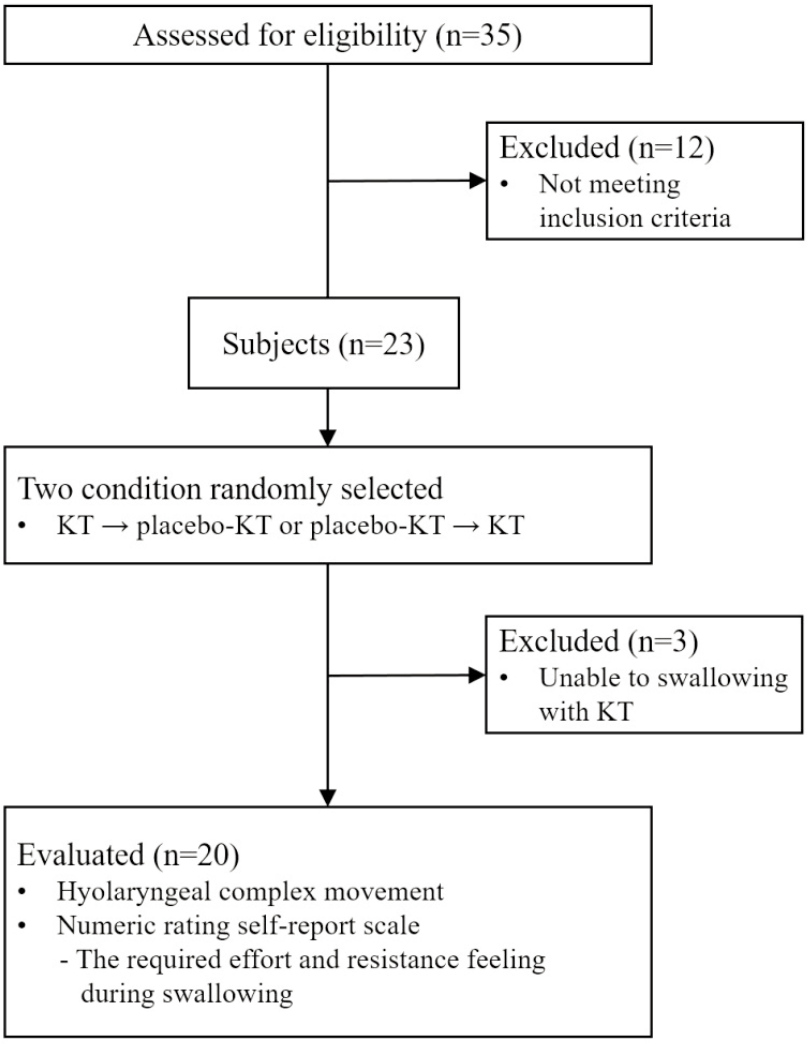

Figure 1. Flow Chart

Kinesiology taping application

The kinesiology tape (BB Tape; WETAPE Inc., Seoul, Korea) was applied by a skilled occupational therapist. In the sitting posture, the subject looked ahead and the head and neck were kept in the neutral position. For the firm attachment of KT, the front of the neck was cleaned with an alcohol swab.

KT was attached in three steps as follows. First, hyoid bone and thyroid cartilage were marked using pen (Figure 2, A). Second, the I-shaped tape was pulled downward to the level of the thyroid notch to wrap the thyroid cartilage and attached to the sternum with an approximate 50-60% stretch (Figure 2, B). Third, the reverse V-shaped tape was attached from the hyoid bone to the medial superior surface of the clavicle with an approximate 50-60% stretch (Figure 2, C). Finally, we covered the hyolaryngeal complex in the horizontal direction to enhance the restriction of movement of the hyolaryngeal complex during swallowing with the firm attachment of the taping with an approximate 70-80% stretch (Figure 2, D). The application of KT was conducted by a skilled practitioner with 7 years of clinical experience.

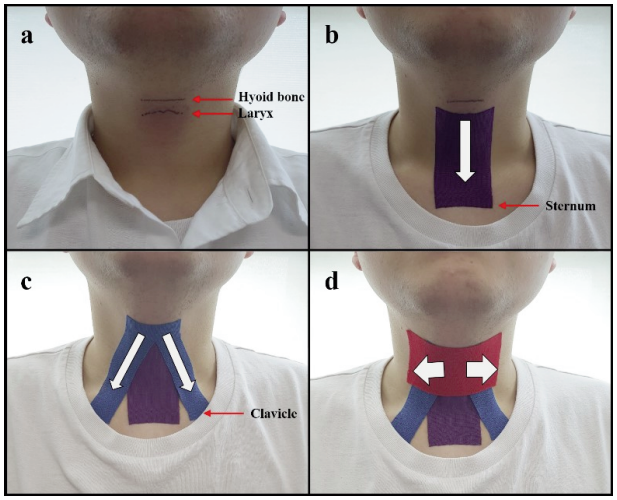

Figure 2 Application of kinesiology taping
(A) Marking in hyoid bone and larynx using pen
(B) I-shaped tape was pulled downward to thyroid notch to wrap the thyroid cartilage and attached to the sternum
(C) Reverse V-shaped tape was attached from the hyoid bone to the medial superior surface of the clavicle
(D) Covering the hyolaryngeal complex in the horizontal direction to enhance the restriction of movement of the hyolaryngeal complex

Placebo KT was applied in the same position, color, and direction as the experimental KT except for the stretch of the taping. Placebo KT was applied without stretching of the tape.

Outcome measurement

This study measured the spatial parameter of hyoid bone movement using the Image-J computer software (Figure 3).[9,10] The swallowing motion files were captured using a frame during VFSS. Hyoid movement was defined as the distance from the resting position to the maximal excursion position during swallowing. The anterior and superior displacements of the hyoid were calculated by the point values (x, y) on each image, which were measured on the resting position image (pre-swallow image) and the maximal excursion image. The anterior displacement (x2 − x1) − (Ox2 − Ox1) and superior displacement (y2 − y1) − (Oy2 − Oy1) were measured. The pre-swallowing image coordinates were x1 and y1, and maximal excursion image coordinates were x2 and y2. The coordinates of the anchor point of the pre-swallow image were Ox1 and Oy1, and those of the excursion image were Ox2 and Oy2. All evaluations were performed as blinding assessment by an occupational therapist and a rehabilitation.

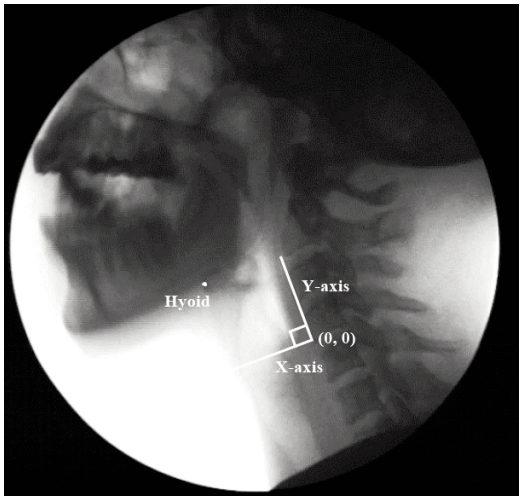

Figure 3. Measurement of the spatial parameter of hyoid bone movement

This study used a 0-to-10 numerical rating self-report scale (NRSS) to record the required effort and resistance felt by the subjects during swallowing in the KT and placebo-KT condition.[16] On the scale, 10 indicated higher effort and resistance feeling during swallowing.

Statistical analysis

The Shapiro Wilk test was used to check the normality of the outcome variables. This study compared differences in the mean values of the KT and non-KT conditions in participants using a Wilcoxon signed-rank test on SPSS software (ver. 18.0 for Windows; SPSS, Chicago, IL, USA). Statistical significance was set at $P<.05$.

RESULTS

Participants

This study was performed on 23 patients with dysphagia after stroke. However, three of these dropped out because they were unable to swallow voluntarily in the KT condition. Therefore, data of 20 subjects were analyzed. The general characteristics of the subjects are shown in Table 1.

Table 1. Characteristics of Participants

Characteristics	Participants (n=20)
Age (year) mean ± SD	63.2 ± 6.7
Gender (male/female)	11/9
Stroke type (infarction/hemorrhage)	12/8
Side of stroke (right/left)	10/10
Dysphagia onset (months)	4.3 ± 2.2

Effect of the hyoid bone movement

In the placebo–KT condition, the anterior and superior movements of the hyoid bone during swallowing were 7.94 mm and 9.30 mm, respectively, whereas in the KT condition, the anterior and superior movements of the hyoid bone during swallowing were 7.04 mm and 7.96 mm, respectively. On comparing the two conditions, the KT condition showed a statistically significant decrease in the anterior and superior movement of the hyoid bone during swallowing than the placebo–KT condition (P=.014 and .002) (Table 2).

Effect of larynx movement

In the placebo–KT condition, the anterior and superior movements of the larynx during swallowing were 8.51 mm and 11.67 mm, respectively, whereas in the KT condition, the anterior and superior movements of the larynx during swallowing were 7.62 mm and 10.50 mm, respectively. Comparing the two conditions, the KT condition showed a statistically

Table 2. Changes of hyoid bone and larynx in parameters placebo–KT and KT conditions in individual

Unit: mm

	Hyoid Bone				Larynx			
	Anterior		Superior		Anterior		Superior	
	Placebo	KT	Placebo	KT	Placebo	KT	Placebo	KT
S1	9.53	7.65	10.64	8.64	8.62	6.32	15.24	12.96
S2	11.18	8.48	9.95	7.95	11.34	8.41	14.23	15.41
S3	7.69	8.39	5.89	7.19	8.64	7.82	9.58	7.25
S4	6.69	6.01	8.92	7.89	7.15	6.64	13.39	10.02
S5	7.37	7.21	8.74	6.89	7.26	7.49	12.21	14.38
S6	8.33	8.42	9.31	6.96	8.36	8.63	13.73	11.47
S7	7.41	5.96	7.76	6.31	8.34	6.12	9.95	6.24
S8	6.56	7.32	9.35	7.45	8.72	5.63	10.95	12.39
S9	9.53	7.74	11.95	8.74	8.64	8.36	14.73	11.69
S10	6.88	5.02	8.35	7.94	10.11	9.11	8.39	9.52
S11	5.07	6.09	7.56	8.98	8.17	6.98	8.69	7.19
S12	8.28	5.87	8.47	8.84	7.65	5.32	10.42	8.96
S13	7.61	5.34	13.49	8.07	8.56	9.01	9.08	8.36
S14	10.85	8.52	8.52	8.91	7.52	6.32	12.93	13.03
S15	7.34	9.96	8.48	7.52	7.26	8.03	12.16	8.91
S16	8.83	6.65	9.61	7.19	9.46	7.98	13.73	12.69
S17	7.41	7.69	5.63	5.36	8.31	9.65	9.95	7.14
S18	6.95	5.55	7.38	8.02	8.22	5.39	10.75	12.95
S19	9.69	7.24	11.58	9.12	8.64	11.96	14.43	11.85
S20	5.78	5.87	14.53	11.28	9.37	7.31	8.91	7.67
Ave. (STD)	7.94 (1.59)	7.04 (1.32)	9.30 (2.25)	7.96 (1.24)	8.51 (1.00)	7.62 (1.63)	11.67 (2.25)	10.50 (2.71)
Diff. (STD)	−0.90 (1.48)		−1.34 (1.70)		−0.89 (1.63)		−1.16 (1.91)	
P–value	.014*		.002*		.025*		.013*	

Mean ± standard deviation, KT: Kinesiology taping
*P<.05 by Wilcoxon test

significant decrease in the anterior and superior movement of the larynx during swallowing than the placebo–KT condition (P=.025 and .013) (Table 2).

Numeric rating self–report scale

In the placebo–KT condition, the required effort and resistance feeling during swallowing were 1.80 and 1.75, respectively, whereas in the KT condition, the required effort and resistance feeling during swallowing were 5.25 and 5.80, respectively. Comparing the two conditions, the KT condition scored significantly higher than the placebo–KT condition in terms of the required effort and resistance feeling during swallowing (P<.001, all) (Figure 4).

Reported side effects

Adverse events (e.g., muscle fatigue, or discomfort) were not reported during the study.

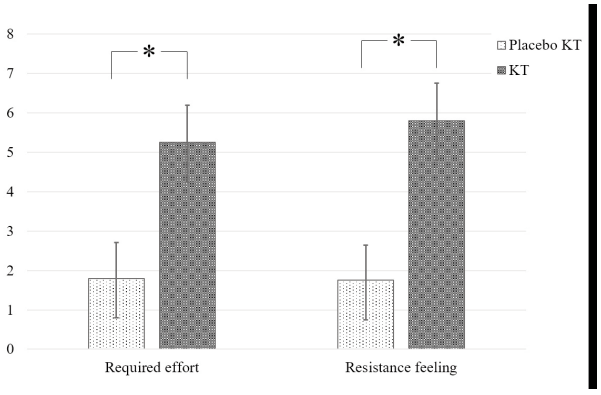

Figure 4. Numeric rating self–report scale (*P<.05)

DISCUSSION

This study investigated the effect of KT on the movement of the hyolaryngeal complex in patients with dysphagia after stroke. In this study, we observed that the attachment of KT to the downward direction from the hyolaryngeal complex restricted the anterior–superior movement of the hyolaryngeal complex during swallowing.

The results of this study can be explained by two main reasons as follows. First, KT has properties of expansibility and contractile forces, and it can be used to suppress the movement of hyolaryngeal complex by physical external force. In this study, KT was attached using two designs (I– and reverse V–shaped KT) to suppress the movement of the hyolaryngeal complex during swallowing. First, the KT was pulled downward from the thyroid cartilage with about 50–60% stretch and was attached to the sternum, producing a potential contractile force of about 50–60% for returning to its original length, which acts as an external force pulling the hyolaryngeal complex downward. This study also applied a reverse V–shaped KT to both clavicles from the hyoid bone. As a result, the KT contractile force is generated, and the hyoid bone is exposed to external force by being pulled downward. Thus, the physical external force of KT is generated from the adhesion, direction, and contractility of the skin and joints, and can be applied to fix or inhibit movement. Lee et al.[17] reported that by applying external force to the hallux metatarsophalangeal joint, KT effectively limits its movement. This supports the methodological aspects applied in this study.

Second, KT applied to skeletal muscle helps to induce immediate muscle activation, which can affect the recruitment of more force during muscle contraction.[18] In this study, KT was applied downward from the hyoid bone to the sternum and clavicles, and the applied area was composed of muscles that pulled down the hyolaryngeal complex, such as the sternothyroid muscle and the omohyoid muscle. Increased activation of these muscles during swallowing contributes to the downward movement of the hyolaryngeal complex, which may play a role in limiting further upward movement. Lin et al.[19] also applied KT to inhibit and facilitate swallowing–related muscles, which is supported by the results of this study.

Additionally, this study evaluated the resistance feeling and required effort during swallowing in KT and placebo–KT conditions using NRSS. As a result, the resistance feeling and required effort with KT were significantly higher than with placebo KT, which is presumed to be because of the efforts and difficulties to overcome and swallow with KT that acts as a resistance.

This study is of clinical significance in suggesting the possibility of using resistance training methods by suppressing the movement of hyolaryngeal complex during swallowing in dysphagia patients with the help of KT applied under the hyoid bone. However, there are some factors to consider when applying this method. The effect of the KT depends on the design, elasticity, direction, and attachment placement. In particular, the degree of stretch of KT is directly related to the strength of resistance during swallowing, so it is thought that it should be applied considering the patient's swallowing ability. Park et al.[15] applied

it to healthy adults with about 80% stretch of KT, but this study applied it to about 50% by lowering the intensity of resistance because it is a patient with dysphagia after stroke Therefore, it is recommended that future studies should be performed by considering various variables such as the patient's swallowing function and severity of dysphagia.

This study has some limitations. First, it is difficult to generalize the results of this study because the sample size is small. Second, this study cannot confirm the changes in movement of the hyolaryngeal complex with a greater or lesser stretch because the KT was applied only with a 50% stretch. Third, this study cannot guarantee the therapeutic effects because KT presents only the possibility of resistance training method by confirming instantaneous change of hyolaryngeal complex movement during swallowing. Lastly, since the stretch of KT was determined by experiential evidence of practitioner, there may be the presence of the human error for. Therefore, it is necessary to investigate the effects of KT's various stretches in future studies.

CONCLUSION

This study demonstrated that KT applied below the hyoid bone inhibited the movement of the hyolaryngeal complex during swallowing. Therefore, overcoming the upward movement of the hyolaryngeal complex through KT, and repeatedly applying effortful swallowing, can have potential therapeutic effects as a resistance training method.

CONFLICT OF INTEREST

The author claims no conflicts of interest.

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