EFFICACY OF FEEDBACK BASED THERAPY FOR DYSPHAGIA IN POST STROKE PATIENTS

ABSTRACT

Background and Purpose

Nearly one third ofstroke survivors experiencing swallowing dysfunction called Dysphagia, in addition to the motor and sensory impairments. Post stroke dysphagia is associated with increased mortality and morbidity due to aspiration pneumonia, and malnutrition.Feedback can be advocated for enhancing outcomes in dysphagia rehabilitation. However, biofeedback in swallowing therapy is not routinely used. Hence, we tested the functional outcome of cumulative effect of surface Electromyograpy(sEMG) biofeedback adjunct to swallowing exercises summated with visual, auditory and tactile feedback which engross and stimulates active participation of the patients during the therapy of dysphagia rehabilitation.

Methods

This study included12stroke patients with swallowing difficulty allocated into control and interventional group with 6 subjects in each. Swallowing function was evaluated using Functional Oral Intake Scale(FOIS), BaselineSurface Electromyography (sEMG) of Suprahyoid muscle and Presence of Nasogastric tube. Interventional group received Feedback based therapy along with conventional therapy for 30 to 40 minutes a day for10 days and control group received conventional therapy for 10 days. The post

interventional outcome of FOIS, Average of surface Electromyography (sEMG)of suprahyoid muscle was evaluated.

Results

The Nasogastric tube was removed in all patients of experimental group after intervention and establishedinitiation of oral feeding. The result showed improvement in functional oral intake scale after intervention. The muscle activity noted in experimental group was greater than the control group ($p<0.05$).

Conclusion

We conclude that Feedback based therapy protocol shows good improvement in post stroke patients with dysphagia. Inclusion of this protocol in therapy may influence standards of care and best practices for post stroke dysphagia patients.

THE REGISTRATION NUMBER: This trial was registered in Clinical Trials Registry – India and the trial registration numberis CTRI/2020/05/025356

Keywords: Dysphagia, Feedback, FOIS, sEMG, Post stroke.

INTRODUCTION

Stroke is one of the major reasonfor disability in India. The incidence rate is 119-145/100,000 based on the recent population based studies (1).In addition to the motor and sensory impairments, dysphagia is acommon impairment after stroke. The incidence of dysphagia following stroke was reported between 30% to 50% during recent times(2). Post stroke dysphagia increases the risk for dehydration, malnutrition, pulmonary complications, and mortality, which all lead to a poor prognosis and affects the quality of life (3). As a result of dysphagia, 43%-50% of stroke patients land up with aspiration pneumonia which increases the mortality rate. Only 10% of stroke related deaths are caused by neurological deficits, while 30% of post-stroke deaths are due to pneumonia resulted from dysphagia(4).

An adultswallows of about 800 to 2400 times a day normally. When timing, coordination, feeling and muscular strength for swallowing are disturbed, this is called dysphagia(5). Impact of Dysphagia include following symptoms, food spillage from lips, taking a long time to finish a meal, poor chewing ability, dry mouth, drooling, nasal regurgitation, food sticking in the throat, poor oral hygiene, coughing and choking, regurgitation, weight loss, repeated chest infections (4). Some patients with severe dysphagia requires a nasogastric feeding tube for months, even to years to compensate for adequate nutrition demand and water intake (6).The structural neuroimaging analysis in poststroke dysphagia patients found that the insular cortex, frontal lobe, temporal gyrus, basal ganglia, postcentral gyrus, precentral gyrus, precuneus, and radial corona were the relevant brain areas for dysphagia and the insular cortex probably had the greatest association with poststroke dysphagia (29).

Physiotherapeutic interventions of Orofacial rehabilitation which aims to maintain and rehabilitate swallowing which vary from breath control, postural adjustment, electrical stimulation, tongue exercises, lipexercises. Biofeedback is often used in physiotherapy to summate the rehabilitation practice of upper and lower motor function. However, biofeedback in swallowing therapy is not routinely used to facilitate the dysphagia rehabilitation (24). This study was conducted to elaborate the strategies of conventional physiotherapy program for dysphagia rehabilitation in post stroke, as physiotherapist are the part of multidisciplinary team addressing the swallowing dysfunction in stroke population.

The process of squeezing and holding the larynx at the peak of the swallow in Mendelsohn maneuver and rapid jaw opening using surface electromyography (sEMG) biofeedback providing visual feedback from the display as well as tactile feedback by palpating the movement of larynx (the rise, squeeze, and fall of larynx)(7). The use of sEMG biofeedback is to increase the effort and the duration of attempted swallow (8). Visual Feedback allows the participant to know real time information of current muscular force production and can aid in relearning the skill. Participants are motivate to make more efforts when try modulating the signals thereby indirectly working on their internal physiological events by improving the muscle recruitment(9).

Generally, the studies were designed to find out the effectiveness of single interventions but none has documented the outcome of combining feedback therapies. while the outcome data from these studies reported improved oral intake in most patients, leaving an open questions, regarding the functional outcome and improvement in muscle activity which may have occurred. Evident data is extremely limited for dysphagia rehabilitation of conventional therapy augmented with feedbackstrategies by biofeedback using sEMG while performing mendelsohn maneuver, effortful swallow and jaw opening to enhance

the activity of suprahyoid muscle along with improvement in swallowing function. We felt a need to formulate a sole dysphagia rehabilitation protocol in post stroke and to study functional outcome of cumulative effect of sEMG biofeedback adjunct to swallowing exercises summated with visual, auditory and tactile feedback which engross and can stimulateactive participation of the patients during the therapy.

METHODOLOGY

This Interventional study was approved by the Ethics committee for thestudent proposal, **(REF: CSP/19/NOV/81/369),** Sri Ramachandra Institute of Higher Education and Research.**Inclusion criteria**: Post stroke of (more than 3 weeks)dysphagia female and male of age 40 to 70 years referred for physiotherapy,hemodynamically stable, Complaints of swallowing and non-oral feeding, Functional oral intake scale less than or equal to two, Mini-mental state examination score of 21 or more than 21.**Exclusion criteria**: Neurological disease other than stroke, Upper gastrointestinal diseases.

PROCEDURE

This Interventional study included 12 subjects diagnosed with Post Stroke of more than 3 weeks duration with dysphagiafrom Sri Ramachandra Medical Centre and Hospital, Porur.Informed consent was obtained from the participants. The consent was obtained from the care givers if the patient could not sign their written consent. Convenient sampling method was used to allocate the patients who met the inclusion criteria into control and interventional group with 6 subjects in each. Swallowing function was evaluated using 7point ordinal, Functional Oral Intake Scale (FOIS) to document the level of swallowing function in post stroke dysphagia for both the control and

experimental groups. BaselinesEMG of Suprahyoid muscle activity was recorded prior to the treatment. Duration of presence of Nasogastric tube was noted.

The skin was prepared by standard skin preparation techniques of cleaning with 70% alcohol (ethanol). sEMG data was recorded using Neurotrac software 4.0 0f VM (Verity Medical Ltd, United Kingdom). Silver chloride adhesive electrodes were used with 10 mm diameter and 20 mm inter electrode distance. The electrodes are placed under the chin, just lateral to midline, anterior to the hyoid bone, thus recording the muscle activity in the submental muscles (m. stylohyoid, m. mylohyoid, m. digastricus). The reference (ground) electrode is positioned away from the muscles of interest. The electrodes are attached to an sEMG device using a sensor cable and the signal from the device is registered on a computer using specialized software. On the horizontal axis the time frame is 30s, the vertical axis shows the electrical activity (measured in microvolt) of the submental muscles. During swallowing, the larynx is elevated and moved forward by the contraction of the supralaryngeal, suprahyoidand submental muscles. sEMG was recorded during dry swallowing.

Patients in both the groups received conventional Neuromuscular electrical stimulation, shaker exercises, postural correction, tongue and lip exercises for 20 minutes, once in a day for 10 days. sEMG was recorded in both the groups, after 10 sessions of therapy. Experimental group received feedback based therapy of hyoid lift maneuver, mendelsohn maneuver, effortful swallow and rapid jaw opening along with biofeedback using sEMG in addition to conventional therapy. On completion of the treatment duration of 10 days, the post interventional outcome of Functional Oral Intake Scale (FOIS). Average EMG output from suprahyoid muscles, presence or absence of Nasogastric tube after intervention was evaluated.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 23.

Within group analysis of sEMG recording of suprahyoid muscles for both control and experimental group was done using Paired t test. Between group analysis of pre and post recordings of sEMG was done using independent t test.Wilcoxon sign rank test was used to find out the changes associated with FOIS within the groups. Mann- Whitney u test was used to compare changes associated with FOIS between the control and experimental group.

RESULTS

Table 1 : Demographic profile

Variables	Control	Experimental
Age [mean(SD)]	**63(10.08)**	**61(13.15)**
Male	**3**	**1**
Female	**3**	**5**
Hemorrhagic CVA	**4**	**2**
Ischemic CVA	**2**	**3**
Lacunar infarcts	**-**	**1**

Table 1: The profile of the stroke patients participated in the study.

Table 2 : Nasogastric tube before and after therapy

Control group			Experimental group		
Patient	Presence of Nasogastric tube		Patient	Presence of Nasogastric tube	
	Pre	Post		Pre	Post
1c	Yes	No	1e	Yes	No
2c	Yes	Yes	2e	Yes	No
3c	Yes	No	3e	Yes	No
4c	Yes	No	4e	Yes	No
5c	Yes	No	5e	Yes	No
6c	Yes	Yes	6e	Yes	No

Table 3:Nasogastric tube was removed for all participants of experimental group after therapy**.** Whereas in control group 4 were removed from feeding tube and 2 of the participants remained with nasogastric tube even after therapy.(c- control group, e- experimental group)

Table 4: Functional Oral Intake Scale

Control and Experimental group								
	Within group						Between group	
	Control			Experimental				
Outcome	**Pre Mean (SD)**	**Post Mean (SD)**	**P^a**	**Pre Mean (SD)**	**Post Mean (SD)**	**P^a**	**P^b**	**P^c**
FOIS	**1.67 (0.52)**	**3.67 (0.52)**	**0.014***	**1.67 (0.52)**	**5 (0.63)**	**0.023***	**1.00**	**0.01***

Table 3: P^a - Wilcoxon sign rank test for pre and post analysis within Control and Experimental group.

P^b - Mann-whitney U test for pre intervention scores between the groups.

P^c- Mann-whitney U for post intervention scores between the groups

The FOIS was significantly improved in both control and experimental group compared with pre intervention results ($p < 0.05$). The pre intervention values are not statistically different between the groups, whereas ($p<0.05$) post intervention scores between the groups were statistically different at the end of the treatment period.

Table 5 : Average sEMG output from suprahyoid muscles within the group.

Group	Dry swallowing Average output Mean µv (SD)	Pre mean (SD)	Post mean (SD)	p value
Control	**Right suprahyoid**	**3.40 (0.64)**	**8.01 (0.93)**	**0.000***
	Left suprahyoid	**3.48 (0.75)**	**7.79 (0.94)**	**0.000***
Experimental	**Right suprahyoid**	**3.44 (0.75)**	**11.59(2.46)**	**0.000***
	Left suprahyoid	**3.51 (0.72)**	**12.56(3.97)**	**0.004***

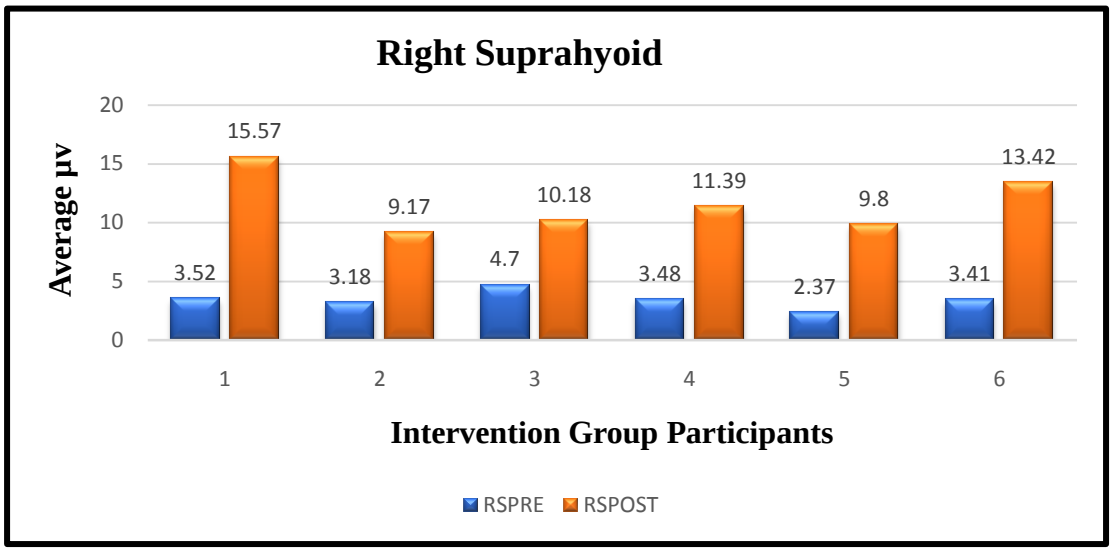
Table 4: Paired t test was used to analyze the pre and post intervention scores within the groups. The result shows increase in muscle activity in both control and experimental groups following intervention when tested within the groups.

Table 6 : Average sEMG output from suprahyoid musclesbetween the groups

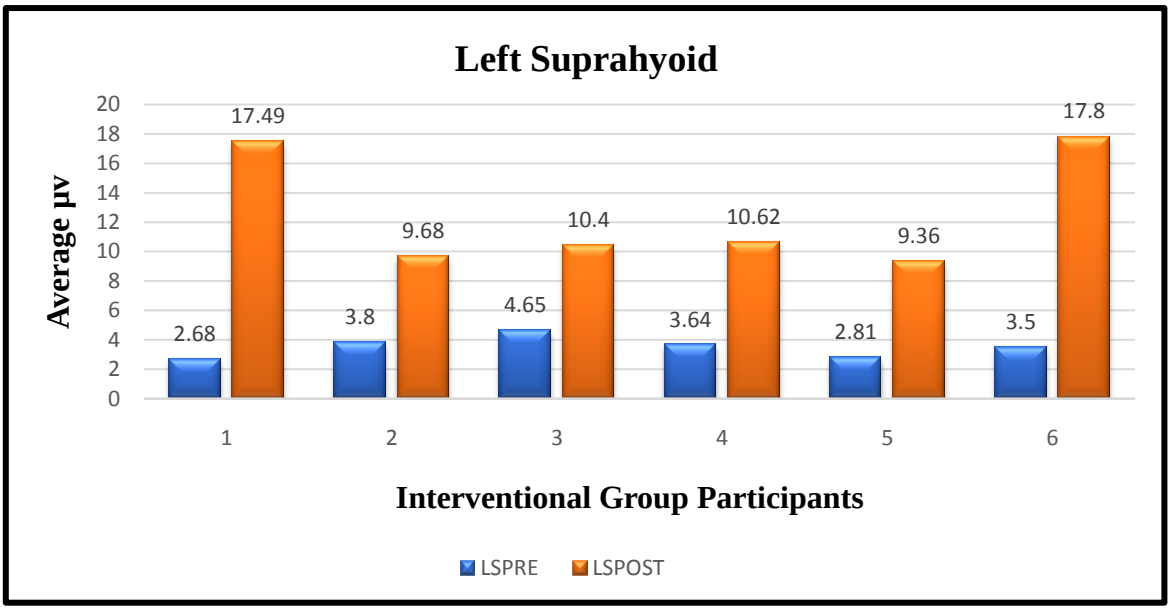
Dry swallowing	Control		Experimental		p value
	PreMean (SD)	Post Mean (SD)	PreMean (SD)	Post Mean (SD)	
Right suprahyoid	3.4(0.642)	8.00(0.931)	3.443(0.75)	11.59(2.46)	0.01
Left suprahyoid	3.475(0.750)	7.7(0.941)	3.513(0.718)	12.56(3.968)	0.02

Table 5: Independent t test was used to analyze the pre and post intervention scores between two groups. A greater muscle activity was recorded in experimental group compared to control group following intervention. ($p<0.005$) post intervention scores between the groups were statistically different.

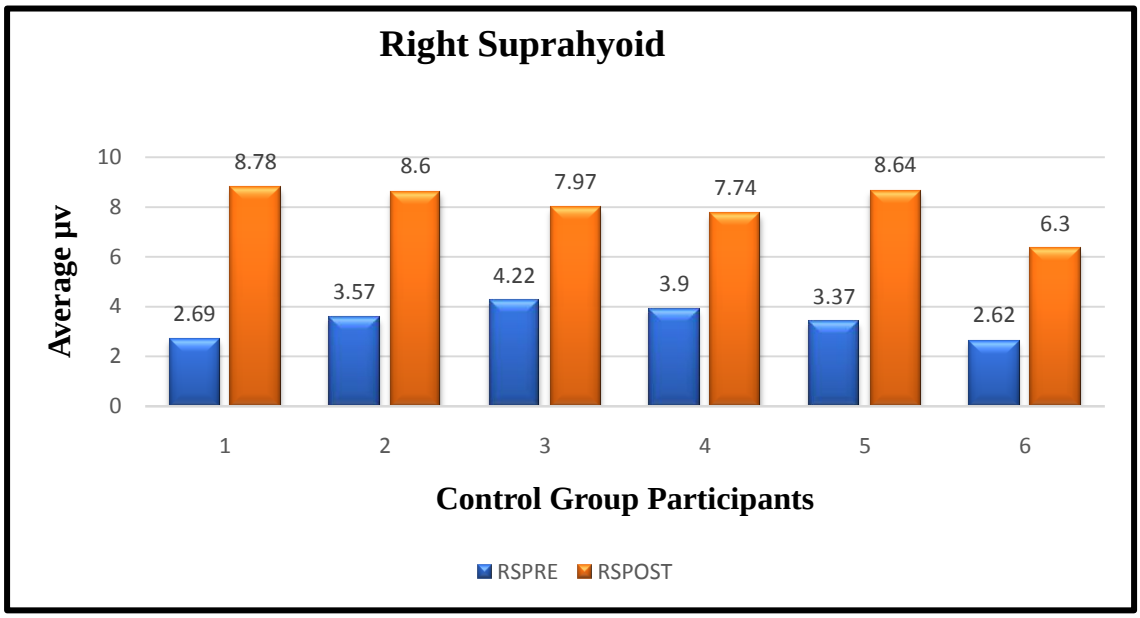
Graph1 : Analysis of Interventional group for sEMG recording of Right suprahyoid



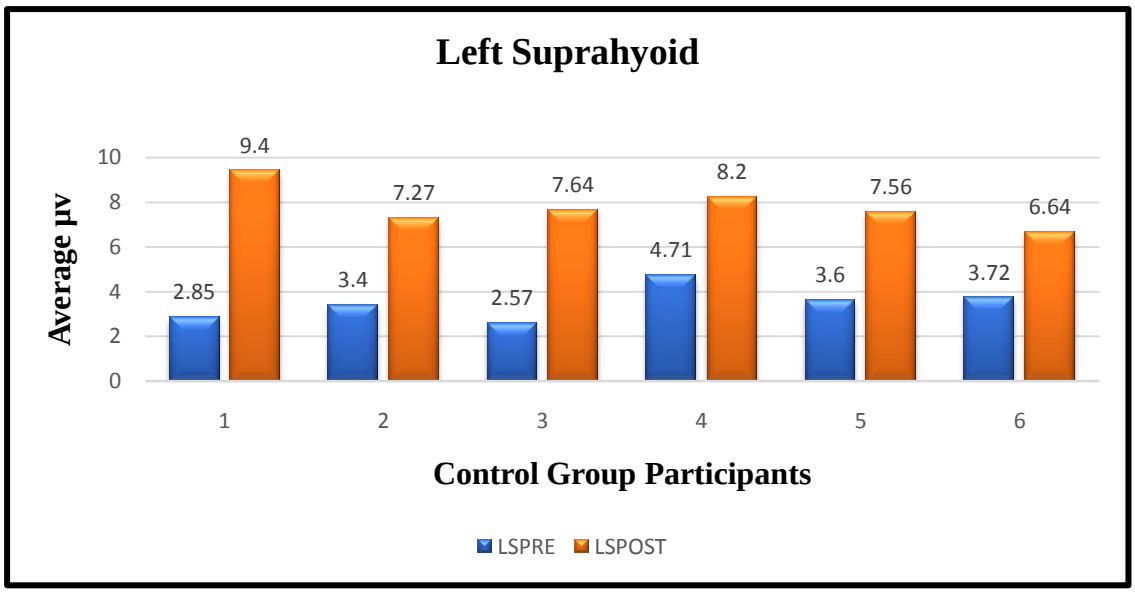
Graph 2 : Analysis of Interventional group for sEMG recording of Left suprahyoid



Graph 3: Analysis of Control group for sEMG recording of Right suprahyoid



Graph 4 : Analysis of Control group for sEMG recording of Left suprahyoid



DISCUSSION

This study was conducted to elaborate the strategies of conventional physiotherapy program for dysphagia rehabilitation in post stroke, as physiotherapist are the part of multidisciplinary team addressing the swallowing dysfunction in stroke population(25) but the therapeutic strategies of physiotherapy which aim to maintain and rehabilitate swallowing may vary from postural adjustment in sitting, positioning of head and neck to electrical stimulation of pharyngeal muscles. Evident data is extremely limited for dysphagia rehabilitation of conventional therapy augmented with feedback based strategies by biofeedback using sEMG while performing mendelsohn maneuver, effortful swallow and jaw opening to enhance the activity of suprahyoid muscle along with improvement in swallow function.

In this study, we have included 12 participants with swallowing dysfunction who scored less than or equal to 2 in FOIS were allocated to control and experimental group with 6 participants in each group. The demographic profile from table 1 shows more female patients 8 out of 12 participated in this study and the mean(SD) age group of control group was 63(10.08) and the intervention group was 61(13.15).

Dependency on Nasogastric tube:

At the start of the treatment all 12 patients were fully dependent on Nasogastric tube (FOIS $\leq$ 3). The level was increased by 2 or 3 points on the FOIS in both groups but, the feeding tube was removed in all patients of experimental group after intervention when compared with control group, establishing 100% success rate. This is also explained in a similar study done byBogaardt et al (2009) where removal of tube established to 75% after the use of surface EMG feedback in chronic dysphagia of stroke patients (17). Whereas in control group, 4 patients became independent of

feeding tube, leaving 2 patients remained on Nasogastric tube for feeding even after treatment.

Functional Oral Intake Scale:

In this study the FOIS of both the group was statistically significant. This may be attributed to the employment of conventional treatment of neuromuscular electrical stimulation of suprahyoid and infrahyoid muscles in both the groups. This result is supported by the recent study of Lee kim et al (2014), which showed NMES combined with traditional dysphagia therapy was a more beneficial treatment for acute/ subacute stroke patients with dysphagia(26).

In a study by Pownall et al (2017), NMES is postulated to improve swallowing function by activating fast twitch muscle fibers (type 2 motor unit fibers), enhancing the muscle strength of suprahyoid which is responsible for anterior and superior movement of the hyoid (4).

Though the swallowing function was significantly improved in both the groups, our results supported the hypothesis i.e, post interventional results of FOIS was improved significantly in experimental group when compared to control group. Hence, Feedback basedstrategies has a better effect on improving swallowing function than the conventional therapy

sEMG of suprahyoid muscles:

Despite the small sample size, there is a significant difference in post EMG activity of suprahyoid muscles of both right ($p=0.02$) and left side ($p=0.01$) which revealed Feedback based therapy had a significant positive effect on increasing the suprahyoid muscle recruitment on dry swallowing.

Zanato et al (2016)reported the highest electrical activity was found in the suprahyoid muscles with values of 9.6μv on the left side and 9.5μv when compared to temporalis and masseter during the swallow of 10 ml water in normal individuals, since the suprahyoid muscles are the elevators of the hyoid bone which is an essential movement for swallowing(22). Hara et al (2018) found jaw opening exercises resulted in greater activation of the SH muscles and further studies of dysphagia rehabilitation, focusing on jaw-opening movements, may contribute to advancements in dysphagia rehabilitation(27).

A review by Frietas et al (2016) states that EMG biofeedback and other biofeedback methods can be effective in real time relearning of the swallowing skill. Motor planning and motor control skills are continuously stimulated and beneficial neuronal plasticity is induced. When visual biofeedback is used, changes occurring in cortical activation, highlighting a cortical reorganization(19). A study by Hoon Kim et at (2017) found the combination of the Mendelsohn maneuver with effortful swallowing can produce strong activation of the suprahyoid muscles implies a large recruitment of muscle fibers which directly have a positive influence on the reduction in aspiration.As per the above mentioned studies, suprahyoid muscle activity was improved (28).

LIMITATIONS

The study was done with a small sample size, there was no long-term follow-up with the study patients.

CONCLUSION

We conclude that Feedback based therapy protocol shows a better improvement in post stroke patients with dysphagia. Inclusion of this protocol in therapy may influence standards of care and best practices for post stroke dysphagia patients.

Consent

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

SOURCE OF SUPPORT:

We received support from Faculty of Physiotherapy, Sri Ramachandra Institute of Higher Education and Research, for recruiting the subjects and collecting data.

DISCLAIMER:

The views in the article are truly expressed by the authors involved in the study and based on the literature support.

RECOMMENDATIONS FOR FUTURE STUDY

1. This study can be replicated on larger samples.

2. A similar study can be conducted on a group with adequate follow-up for 3 months.

3. A similar study can be conducted with assessment of quality of life and clinical indicators at repeated intervals.

DECLARATION OF INTERESTS:

The authors declare no conflict of interest.

TABLES

TABLE-6: INTERVENTIONAL EXERCISE PROTOCOL

The following exercise are trained along with SEMG biofeedback of each exercisefor 5 times once daily for 10 days.

S.no	Exercises	Instructions

1	Hyoid lift maneuver	1. Multiple small pieces of paper placed on a towel in front of the patient. 2. Place a straw in mouth and ask to suck the piece of paper on the straw, allowing the paper to get picked up by the tip of the straw. 3. Keep sucking on the straw ask to carry the straw over to a cup, and stop sucking to release the paper into the cup. 4. Ask to place all of the pieces of paper into the cup. Gradually increases from 3 to 5 and around 10 pieces.
2	Effortful Swallow	1. Push tongue up to the roof of the mouth 2. Swallow "hard" with effort 3. Pretend as like swallowing a golf ball 4. Ask to do 3 sessions of this exercise per day
3	Mendelsohn	1. Begin a regular swallow 2. Place middle three fingers on Adam's apple. Feel the larynx move in an upward direction and squeeze muscles 3. Ask to face the screen and instructed the participant to swallow "long and strong" with a squeeze at the peak of the swallow for 3 to 4 seconds
4	Jaw-opening exercise.	Ask to open the jaw to the maximum extent and maintain this position for 10 s.

TABLE-7: CONVENTIONAL THERAPY

1	Neuromuscular electrical stimulation	Electrical stimulation was given for a period of ten days once daily. The following are the parameters for stimulation: Current- faradic, Contraction- 90. Placement of electrodes-on either side of midline above the lesser horns of the hyoid bone(anterior neck)
2	Shaker Exercise	Lying on the back on the bed. Keeping shoulders flat against the bed, and lifting up the head, bringing the chin down to the chest. Keeping the head lifted for 60 seconds, and then lower the head and rest for 60 seconds.

3	Lip Press	Tightly close upper and lower lip against each other for 5 seconds, repeat 10 times
4	Tongue Push Side to Side	Extend tongue out of mouth as far as possible, patient attempts to move tongue toward the corner of mouth and against the cheek, hold for 5 seconds, repeat 10 times.
5	Tongue Side to Side	Move tongue out of mouth, rotate tongue tip to left side of mouth, hold for 5 seconds, then to right side of mouth, hold for 5 seconds, repeat 10 times.
6	Tongue Push Forward	Open mouth and move tongue such that tongue tip rests against the lower lip, patient attempts to move tongue forward, hold for 5 seconds, repeat 10 times.
7	Tongue Push Up	Extend tongue out of mouth, patient attempts to move tongue upward against the upper lip, hold for 5 seconds, repeat 10 times

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