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Effects Of Mendelsohn Maneuver On Measures Of Swallowing Duration Post-Stroke

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No Abstract

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Introduction

The Mendelsohn Maneuver, or voluntary prolongation of hyolaryngeal elevation at the peak of the swallow, has been used to treat patients with pharyngeal dysphagia for many years[1–3]--sometimes as a compensatory strategy to help the bolus pass more efficiently through the pharynx[4–6] and sometimes as part of a rehabilitative exercise program[7–10]. Early reports on the Mendelsohn maneuver suggested use of the maneuver increases laryngeal elevation and maximal hyoid superior displacement and provides an immediate effect in prolonging the duration of opening of the upper esophageal sphincter (UES) but not the diameter[1–6]. Since the initial reports, more data have emerged supporting the physiologic effects of the Mendelsohn maneuver on the act of swallowing, but most papers consider only the immediate effects of the maneuver on small numbers of normal participants or patients[11–14].

Rehabilitation, like compensation, addresses deficits in swallowing physiology[15], but rather than providing an immediate change in the physiology of swallowing, an exercise designed to rehabilitate should provide a lasting effect on swallowing. A few studies provide outcome data on patients with dysphagia who have used the Mendelsohn maneuver as part of a collection of exercises with the goal of rehabilitation, but none have used the maneuver in isolation and reported on change in swallowing physiology as a result[7–9]. While use of the maneuver shows promise when included as part of a broader regimen of treatment, the specific physiologic effects of the Mendelsohn maneuver on patients with dysphagia cannot be determined without investigation of the maneuver in isolation. The studies reporting positive outcomes incorporating the maneuver also employed techniques, such as head turns, chin tucks, supraglottic swallows, effortful swallows, and the Shaker exercise, amongst others. Moreover, while outcome data from these studies reported improved oral intake in most patients without development of pneumonia or other negative health consequences, specific changes in swallow physiology were not reported, leaving open questions regarding the functional and physiologic changes which may have occurred, as well as the actual cause of those changes (i.e., time, swallowing food and liquid, doing exercises—and which exercises). These studies have clearly demonstrated that dysphagia rehabilitation is possible in certain patients post-stroke; but without specifically examining the use of individual exercises in isolation, the contribution of any particular exercise cannot be clearly defined. In other words, while the Mendelsohn maneuver appears to have an immediate effect on hyolaryngeal movement and duration of UES opening, no data exist to define what, if any, lasting effect use of the Mendelsohn maneuver over time may have on the physiology of swallowing when the Mendelsohn maneuver is no longer employed.

Based on the reports regarding the immediate effects of the Mendelsohn maneuver on swallowing, we would anticipate that if long term changes result from use of the Mendelsohn as an exercise, they would include duration of hyolaryngeal elevation, anteriorly an/or superiorly, and, consequently, duration of opening of the upper esophageal sphincter.[1–6] When swallowing, the hyoid bone and thyroid cartilage begin to rise, then the hyoid bone begins to move superiorly and anteriorly in a quick burst of movement. The path of this movement can vary but is often triangular, moving superiorly, then anteriorly and then back to rest or vice-versa (anteriorly, then superiorly, then back to rest). These durations can be measured as “duration of hyoid maximum anterior excursion” (DOHMAE) and “duration of hyoid maximum elevation” (DOHME)[16]. These do not measure the duration of hyoid movement from start to finish but rather the duration that the hyoid remains at it’s maximum anterior and superior points. Duration of hyoid movement from start to finish is measured as “pharyngeal response duration” (PRD). Movement of the hyoid, especially the anterior movement, should create a traction pull on the cricoid cartilage which allows for prolonged opening of the UES[2], which can be measured as “duration of UES opening” (DOUESO)[16].

The purpose of this investigation was to determine if any lasting changes would occur in swallowing physiology as a result of intensive exercise using the Mendelsohn maneuver. Our hypothesis was that measures of the duration of hyoid movement and the duration of UES opening would significantly improve. We also hypothesized that measures of bolus flow—penetration/aspiration and pharyngeal residue—would improve as a result of these changes. In addition, we wanted to obtain some preliminary information regarding dose-response, which could be examined by comparing results after 10 sessions and 20 sessions of treatment. Other measures of oral and pharyngeal swallowing duration were analyzed, as well as outcomes on the Dysphagia Outcome and Severity Scale[17].

METHODS

Participants

Participants were recruited through advertising and referrals at The University of Arkansas for Medical Sciences Medical Center, as well as word of mouth via area speech-language pathologists. All participants provided written consent and all procedures were approved by the hospital’s Institutional Review Board.

Eighteen individuals, age 21 and older, who suffered a stroke and were dysphagic participated in this investigation (see Table 1). Each was between six weeks and 22 months post stroke (9.5 months average) at the time of participation. Based on limited data in the literature and numerous potential impacts on pharyngeal swallowing, we chose to broadly enroll patients who were post-stroke for this pilot study. Patients who had pharyngeal dysphagia characterized by any apparent reductions in hyolaryngeal elevation and or UES opening and evidence of some type of residue in the pharynx were invited to participate. These were visual judgments made by the principal investigator during the initial VFSS. Each participant also had to be on a restricted diet, defined by need for a nasogastric, jejunostomy, or percutaneous endoscopic gastrostomy tube, or an oral diet that was altered in any way due to swallowing difficulty. Individuals with an absent swallow were not included in the study. All individuals had to demonstrate at least a minimal functional swallow with some material passing through the UES. Aspiration was not required for participation.

All participants scored 75 or higher on the Modified Mini-Mental State Examination. Individuals with current/history of tracheotomy or other structural alteration to the swallowing mechanism, history of swallowing problems prior to the stroke, progressive neurologic disease, or cognitive and/or physical problems which would have impeded understanding or completion of the therapeutic tasks were excluded. A history questionnaire and a cranial nerve/oral motor screen helped determine the exact nature of the stroke and further define overall impairment. MRIs or CT Scans were obtained when available. In the absence of neuroimaging information, a neurological examination was performed by the study physician.

Each participant underwent an initial VFSS to ensure physiologic fit with the study as well as a baseline of swallowing function. If swallowing function appeared to be normal or did not meet the above inclusion criteria related to swallow physiology the participant was withdrawn from the study. Each remaining individual was randomized, via pre-study blinded number drawing, into one of two groups: Group A received two weeks of treatment followed by two weeks of no-treatment (BBAA) and Group B received two weeks of no treatment followed by two weeks of treatment (AABB). VFSSs were conducted at the end of each week of the study (A or B) to allow for dose-response comparisons of baseline measures of swallowing with measures at 1 and 2 weeks post treatment and no-treatment.

Measures

Videofluoroscopic Swallowing Studies (VFSS)—Eighteen participants were recruited to participate in this study over nearly five years. Even though the overall duration of the study was protracted and some methods of data acquisition varied between subjects, they were kept constant for each participant as to not impact pre- and post-measures. The majority of VFSSs (N=13) were conducted using a Shimadzu Corporation (Columbia, MD) Digital Fluoroscope (Model F100-02) and were transferred to a KAY Elemetrics Swallow Station (now KAY/PENTAX, Montvale, NJ). Due to the logistics of a hospital renovation and a few subjects being evaluated at another local hospital, 5 studies were recorded directly onto a Sony S-VHS through a FOR-A (Fort Lee, NJ) 100 millisecond videotimer (model VTG 33). Data from the KAY swallow station were also transferred to a JVC (Wayne, NJ) SVHS/DVD player (model SR-MV40) through the videotimer. No loss of imaging occurred during the transfer. This method helped ensure blinded review of studies. All recordings were 30 frames per second but were analyzed to the 100th of a second using the videotimer.

Participants swallowed three 3 mL thin liquids (E-Z-HD Barium sulfate powder for suspension and water/50-50; approximately 14 centipoise) and three 3 mL purees (3 parts applesauce to 1 part barium powder) for each study. The studies were brief (6 swallows with less than 1 minute fluoro) in comparison to typical clinical studies (12–15 swallows and 4–5 minutes fluoro) to limit radiation exposure. All swallows were viewed in the lateral plane with a view of the oropharyngeal area—including the hard palate superiorly, the cricopharyngeal area inferiorly, the lips anteriorly, and the posterior pharyngeal wall posteriorly. Patients were instructed to hold the bolus until they were asked to swallow and to use subsequent swallows, if needed, to clear the bolus.

Duration measures, analyzed using the JVC SVHS/DVD player (model SR-MV40) with frame by frame viewing, are defined in Table 2. Our primary measures (DOHME, DOHMAE, and DOUESO) were movement durations for specific structures, as was pharyngeal response duration (PRD), which is the total duration on hyoid movement. Duration measures representing bolus flow (i.e., OTD, PTD, TSD) were also rated. In addition to measures of swallowing duration, each swallow was rated on an 8-point penetration-aspiration scale[18–19], a scale of oropharyngeal residue (0 = none, 1 = trace coating, 2 = pooling)[20], and the DOSS[17]. The 8-point penetration-aspiration (P/A) scale rates P/A on the depth of the misdirected bolus into the airway (i.e., above, on, or below the vocal folds) and the participant's response to it (i.e., coughed but did not clear, coughed and cleared, no cough). A rating of 1 is no P/A, 5 is penetration to the vocal folds, and 6 and greater are aspiration events. The DOSS is a seven point scale where 7 indicates normal swallowing and 1 and 2 indicate severe dysphagia where nothing is allowed by mouth or only therapeutic feedings. Scores in the 3–5 range indicate mild to moderate impairment where diets are adjusted and compensatory strategies are used.

The PI was the primary person responsible for data analysis. All measures for data analysis were rated from tapes and DVDs by the PI and not at the time of the study. All SVHS tapes and DVDs were labeled with numbers corresponding to participants. In reviewing individual tapes there was no way to know whether ratings were being made for swallow studies after periods of treatment or no-treatment as no marks identifying the order for each participant were present.

Treatment Sessions—During treatment weeks (B weeks), participants were seen twice a day for sessions lasting between 45 minutes and one hour with a 2–3 hour break in between sessions depending on participants' schedules and availability. Each participant was taught the Mendelsohn maneuver, the process of squeezing and holding the larynx at the peak of the swallow, using surface electromyography (SEMG) biofeedback. SEMG biofeedback was provided via a two channel Pathway MR-20 (Prometheus Group, Dover, NH). The electrode pad was placed submentally at midline halfway between the mental symphysis and the tip of the hyoid bone. Ground and active electrodes are linear on the pad and are not adjustable. The signal derived from muscle activity was rectified and low pass filtered to produce a smooth signal. SEMG tracings were used only for participant biofeedback. Treatment sessions were administered primarily by the PI with some assistance from a study clinician once participants were well-trained with the treatment protocol.

Session 1 focused on defining and demonstrating the procedure, as well as teaching the patient to do the maneuver correctly. The PI demonstrated the maneuver and provided visual feedback from the computer as well as tactile feedback via laryngeal palpation (the participant feeling the rise, squeeze, and fall of the PIs larynx). In cases where it was more difficult to determine whether swallows were actually occurring, cervical auscultation was employed along with laryngeal palpation for auditory and tactile confirmation. Prior to each swallow, dental swabs were dipped in ice water and delivered to the mouth to provide a small amount of water. It was not our intent to provide a bolus swallow but simply to moisten the mouth so swallowing would be possible throughout the session. After observing the PI, the participant attempted to replicate the clinician's swallow, palpating his own larynx and watching the SEMG tracing on the computer screen.

Coaching and correcting continued with sessions 2, 3, and, to some extent, throughout the study. Beginning with session 2 on the first day, each participant began the standard regimen of treatment of 30 to 40 swallows per session utilizing the Mendelsohn maneuver. Participants were first baselined—meaning they were asked to swallow hard without looking at the computer. An SEMG target line for amplitude was then set at 5 microvolts above their mean established from three baseline swallows. This was simply to ensure the swallows were made with sufficient strength to recruit muscles. The clinician then asked the participant 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. The dental swab was delivered to the participant's mouth by the clinician and the participant watched the video monitor and performed the maneuver. The clinician froze the video frame after each swallow and provided visual and verbal feedback regarding the strength (amplitude) and duration (seconds) of the swallow. Specifically, the following were pointed out to the participant: 1) the onset and offset points and the duration of the swallow—including the initial rise of the SEMG tracing, which should appear similar to a straight back chair; 2) the peak amplitude, as provided by the Prometheus software; 3) the duration of the current swallow as compared to the previous swallow.

Forty swallows per session were targeted, but participants were allowed to stop at a minimum of 30 if they showed signs of uncomfortable fatigue. At least 30 Mendelsohn swallows were completed during each treatment session. A successful Mendelsohn swallow meant the participant was able to swallow and sustain laryngeal elevation for approximately 2 seconds or greater. Using SEMG for biofeedback, all participants were able to swallow and sustain some semblance of laryngeal elevation for approximately 2 seconds throughout treatment.

Data Analysis

VFSS data were gathered across five points, including an initial study and four more which occurred after each week of enrollment, treatment or no-treatment. Our primary comparison was between ratings of DOHME, DOHMAE, and DOUESO after two weeks of treatment and two weeks of no-treatment, though comparisons were made after 1 week and 3 weeks to consider dose-response. Due to the small size of our sample, we did not have enough power to perform a repeated measures analysis of variance. As our objectives were exploratory in nature, we treated the data points as independent measures and utilized T-tests for independent groups (A versus B). A Bonferroni adjustment was used for stricter control of family wise error rate moving the acceptable p value from .05 to .017. All other data—additional duration measures, residue on a 3 point scale, penetration/aspiration on an 8 point scale, and swallowing severity on the DOSS 7-point scale are provided descriptively.

Intrajudge reliability was derived by having the PI re-analyze a random selection of 10% of all VFSS measures. Interjudge reliability was derived by having a second clinician analyze a random selection of 10% of VFSS measures. The second clinician was a certified speech-language pathologists with at least 100 hours of experience with VFSS, and was trained to criterion prior to the initiation of the study. Some interjudge reliability ratings were made without blinding to name, but the reliability clinician was never aware of treatment condition. All measures of reliability were analyzed using intraclass correlation coefficients (ICC).

Interjudge reliability was high for all measures. ICCs for the primary measures were as follows: DOHME = .749, $p = .000$; DOHMAE = .775, $p = .000$; DOUESO = .649, $p = .002$. Intrajudge reliability as follows: DOHME = .787, $p = .000$; DOHMAE = .842, $p = .000$; DOUESO = .689, $p = .002$. Intra- and interjudge reliability for all other measures was significant with ICCs ranging from a low of .556 ($p = .000$) for OTD to a high of .998 ($p = .000$) for PTD.

RESULTS

Table 3 provides results for the primary outcome measures of DOHME, DOHMAE, and DOUESO.

Pre-treatment mean durations are compared with mean durations after one week of treatment, two weeks of treatment, one week of no-treatment and two weeks of no-treatment. Bear in mind that treatment weeks did not always occur after no-treatment weeks. In roughly half the cases, no-treatment periods occurred after treatment periods and could, therefore, have been influenced by the prior two weeks of treatment. Results indicate all duration measures improved (increased) during treatment weeks and worsened (decreased) during no treatment weeks. Results after two weeks of treatment were better than results after one week of treatment, and results after two weeks of no-treatment were worse than results after one week of no-treatment with the exception of DOUESO, which made a non-significant improvement in respective no-treatment weeks. Improvements in DOHME and DOHMAE were significant ($p = .011$ and .009 respectively) at two weeks post-treatment. No other results were significant. Results for these measures are also presented in Figure 1.

Table 4 provides means for all other measures at study initiation, post two weeks of no-treatment, and post two weeks of treatment. Results for pharyngeal response duration (PRD), which measures the duration of hyoid movement from start to finish, trended with DOHME and DOHMAE, getting worse during periods of no-treatment and better during periods of treatment. No other measures trended this direction. Differences between treatment and no-treatment weeks were minimal, at best, for stage transition duration 1 (head of bolus), stage transition duration 2 (first barium in pharynx), pharyngeal transit duration, penetration/aspiration, vallecular residue, pyriform residue, and dysphagia severity (DOSS) ratings.

DISCUSSION

"The fundamental purpose of Phase I research is selecting a therapeutic effect, identifying it if present, and estimating its magnitude"[21]. While the Mendelsohn maneuver is not new, no prior research has sought to determine the therapeutic effects of the maneuver when administered as an exercise in isolation to patients. Compensatory, or immediate, effects are only useful in as much as a maneuver, or strategy, is employed. Data on normal participants and case studies performing the Mendelsohn maneuver in isolation during bolus swallows [1–6] has shown improved hyolaryngeal movement and UES opening. For the current investigation, we hypothesized that duration of superior and anterior maximal hyoid movement would be prolonged, as well as duration of UES opening. In fact, this was the case. Data show that DOHME (hyoid elevation) and DOHMAE (hyoid anterior excursion) significantly improved (were prolonged) during VFSS evaluation of swallowing after treatment weeks and did not improve after no-treatment weeks. Research has previously reported that the duration of hyoid movement anteriorly and superiorly is reduced post-stroke compared to normals[22]. Such reductions could affect other aspects of swallowing, including duration of UES opening and bolus flow. Duration of upper esophageal sphincter opening (DOUESO) also improved during treatment weeks compared to no-treatment weeks, though results were not statistically significant. With a larger sample, it is very possible this trend would continue and become significant.

We also sought to provide initial data regarding dose-response. VFSSs were performed after each week of enrollment, treatment or no-treatment. Data clearly suggest that while improvement was made in all three measures after 10 sessions of treatment, effects were much greater after 20 sessions. It is very possible that continuing use of the exercise over time, possibly with treatment sessions spread out for cycles of work and rest, would continue to enhance therapeutic effects and provide greater impact on additional measures of swallowing function, including DOUESO. Prior studies employing the Mendelsohn maneuver have reported success with sessions once or twice daily over a 1 to 2 week period providing intense neuromuscular rehabilitation in an effort to improve both the strength and coordination of the swallow[7–9]. Part of the rationale for this regiment of treatment lies in the concept that swallowing post-stroke can become not only weak but discoordinated[9], and more coordinated "patterns" of swallowing activity occur with more intensive treatment. Pure strength training, on the other hand, may benefit not only from "overload" but also periods of rest scheduled over a longer period of time[23]. At the time this study was initiated, the investigators chose the more intensive approach as outlined in the related studies, but future research should examine different treatment regimens of duration and intensity.

Effects on Other Measures of Swallowing

As Table 4 indicates, few other measures were affected by exercise with the Mendelsohn maneuver in this study. These results are not terribly surprising, however. Dysphagia is a complex disorder and we did not expect to find major reductions in dysphagia severity with two weeks of one type of exercise. Pharyngeal response duration trended the way of DOHME and DOHMAE. This makes perfect sense in that all three are different measures of the duration of hyoid movement. We hypothesized the hyoid would be affected by this exercise, and this was the case. Measures of bolus flow, however, may be affected by factors other than hyoid movement—i.e., pharyngeal muscle strength, epiglottic tilt and seal, or tongue base strength.

With improvements in the duration of UES opening, pyriform sinus residue should logically improve more than it did in this study. Our broad inclusion criteria allowed us to consider many possible effects of the maneuver on swallowing physiology but likely impacted this measure. Had more participants demonstrated moderate to severe pyriform residue, then results for this rating may have improved more substantially. Likewise, penetration/aspiration might have improved more if only individuals with post-swallow aspiration from the pyriform sinuses had been included. The current results indicating improvements in duration of hyoid movements and UES opening lend support to future studies with more specific focus on bolus flow in the form of pyriform sinus residue and post-swallow aspiration. Such studies should include larger numbers of participants and examine different intensities of treatment over varying durations of time. Additionally, the effects of the exercise on swallowing physiology should be examined over longer periods of time than one month. Outcome measures at 6 and 12 months should be examined.

Study Limitations

Our results are derived from a small sample of stroke patients. Our primary measures improved in the direction we hypothesized but only 2 of the 3 reached a level of significance. Larger numbers are needed in future investigations, as are variations in treatment regimens, duration, and intensity. Also, we wanted to examine the "post-acute rehabilitation but not necessarily chronic population," but individuals who met the specific criteria and were willing and able to participate were limited. Data collection took twice as long as expected and participants were enrolled up to nearly two years post-stroke. Some of these could easily be classified as chronic. Comparing results of individuals less than one year post-stroke to those two years and beyond would provide valuable information regarding the recovery potential at different points in the rehabilitation process.

CONCLUSION

Our exploratory study indicates the Mendelsohn maneuver, used as a rehabilitation exercise, can improve the duration of hyoid maximum anterior and superior movement and impact the duration of UES opening. These results are consistent with reports on use of the maneuver as a compensatory strategy but present the maneuver as an option for longer lasting changes in the target areas of swallowing physiology. With longer enrollment in treatment and, perhaps, combined with other treatments, it can potentially improve bolus flow and dysphagia severity. More research is needed. Additional measures of biomechanical movements—such as the extent of hyolaryngeal movement and UES opening—are currently being analyzed.

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References

1. Mendelsohn MS, McConnell FM. Function in the pharyngoesophageal segment. Laryngoscope. 97(4):483–489. [PubMed: 3561135]
2. Kahrilas PJ, Logemann JA, Krugler C, Flanagan E. Volitional augmentation of upper esophageal sphincter opening during swallowing. Am J Phys. 260(3 pt 1):G450–456.
3. Logemann, JA. Evaluation and treatment of swallowing disorders. 2. Austin: Pro-ed; 1998. p. 221-222.
4. Lazarus C, Logemann JA, Gibbons P. Effects of maneuvers on swallowing function in a dysphagic oral cancer patient. Head & Neck. 1993; 15:419–24. [PubMed: 8407314]
5. Lazarus C, Logemann JA, Song CW, Rademaker AW, Kahrilas PJ. Effects of voluntary maneuvers on tongue base function for swallowing. Folia Phon et Logoped. 2002; 54:171–6.
6. Bodén K, Hallgren Å, Hedström H. Effects of three different swallow maneuvers analyzed by videomanometry. Acta Radiologica. 2006; 47:628–33. [PubMed: 16950694]
7. Bryant M. Biofeedback in the treatment of a selected dysphagic patient. Dysphagia. 1991; 6:140–4. [PubMed: 1914542]
8. Huckabee ML, Cannito MP. Outcomes of swallowing rehabilitation in chronic brainstem dysphagia: a retrospective evaluation. Dysphagia. 1999; 14:93–109. [PubMed: 10028039]
9. Crary MA, Carnaby GD, Groher ME, Helseth E. Functional Benefits of Dysphagia Therapy Using Adjunctive sEMG Biofeedback. Dysphagia. 2004; 19:160–4. [PubMed: 15383945]
10. Oh TH, Brumfield KA, Hoskin TL, Kasperbauer JL, Basford JR. Dysphagia in inclusion body myositis. Am J Phys Med Rehabil. 2008; 87:883–9. [PubMed: 18936555]
11. Perlman AL, Grayhack JP. Use of the electroglottograph for measurement of temporal aspects of the swallow: preliminary observations. Dysphagia. 1991; 6:88–93. [PubMed: 1935264]
12. Miller JL, Watkin KL. Lateral pharyngeal wall motion during swallowing using real time ultrasound. Dysphagia. 1997; 12:125–32. [PubMed: 9190097]
13. Ding R, Larson CR, Logemann JA, Rademaker AW. Surface electromyographic and electroglottographic studies in normal subjects under two swallow conditions: normal and during the Mendelsohn Maneuver. Dysphagia. 2002; 17:1–12. [PubMed: 11820381]
14. Wheeler-Hegland KM, Rosenbek JC, Sapienza CM. Submental sEMG and hyoid movement during Mendelsohn Maneuver, effortful swallow, and expiratory muscle strength training. J Sp, Lang, Hear Res. 2008; 51:1072–87.

15. Huckabee, ML.; Pelletier, C. Management of adult neurogenic dysphagia. San Diego: Singular; 1998. p. 4

16. Robbins J, Hamilton JW, Lof GL, Kemptster GB. Oropharyngeal swallowing in normal adults of different ages. Gastroenterol. 1992; 103(3):823–829.

17. O'Neil KH, Purdy M, Falk J, Gallo L. The Dysphagia Outcome and Severity Scale. Dysphagia. 1999; 14:139–45. [PubMed: 10341109]

18. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. Dysphagia. 1996; 11:93–8. [PubMed: 8721066]

19. McCullough GH, Rosenbek JC, Robbins JA, Coyle JL, Wood JL. Ordinality and intervality of a penetration-aspiration scale. J Med Sp-Lang Path. 1998; 6:65–72.

20. Robbins JA, Kays SA, Gangnon RE, Hind JA, Hewitt AL, Gentry LR, Taylor AJ. The effects of lingual exercise in stroke patients with dysphagia. Arch Phy Med Rehabil. 2007; 88:150–158.

21. Robey R. A five-phase model for clinical-outcome research. J Comm Dis. 2004; 37:401–411.

22. Burkhead L, Sapienza CM, Rosenbek J. Strength-training exercise in dysphagia rehabilitation: principles, procedures, and directions for future research. Dysphagia. 2007; 22:251–265. [PubMed: 17457549]

23. Kim Y, McCullough GH. Maximal hyoid excursion in poststroke patients. Dysphagia. 2010; 25(1): 20–25. [PubMed: 19655199]

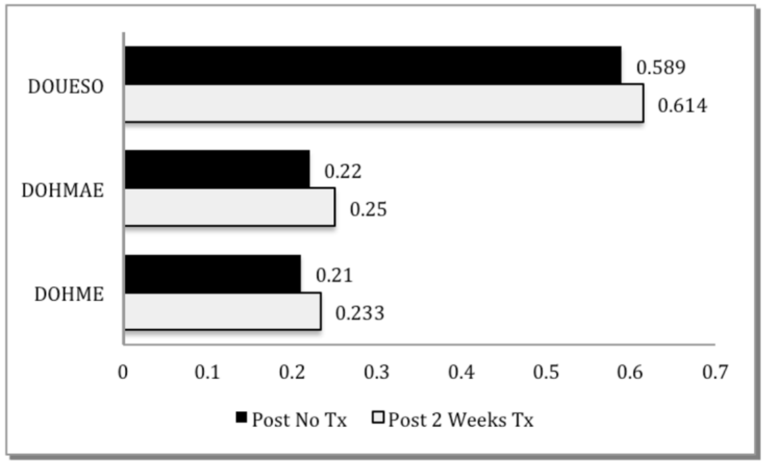

Figure 1.
Graph of primary duration measures after two weeks of no treatment versus two weeks of treatment. DOUESO = Duration of opening of the upper esophageal sphincter. DOHMAE = Duration of hyoid maximum anterior excursion. DOHME = Duration of hyoid maximum elevation.

Table 1

Participant demographics.

Participant	Age	Gender	Site of Lesion	Months Post
1	70	M	L Medulla	18
2	42	M	R Brainstem	15
3	69	M	IC SAH	16
4	58	F	L SAH	22
5	57	F	L Brainstem	12
6	88	M	B White Matter	8
7	61	M	L Brainstem	2
8	84	F	Nonspecified	1.5
9	73	M	R Frontal Lobe	2
10	86	F	R Corona Radiata	3
11	55	F	Left IC/Pons	8
12	70	F	R Medulla	12
13	54	F	Nonspecified	6
14	73	M	Nonspecified	18
15	66	M	L Basal Ganglia	9
16	88	M	R Brainstem	15
17	86	M	R Brainstem	2
18	83	M	R Temporal & Insula	4

L = left; R = right; B = bilateral; IC = internal capsule; SAH = subarachnoid hemorrhage;

Table 2

Oropharyngeal Duration Measures

Abbre-Measure viation		Description of Measure
		PRIMARY MEASURES
DOHME	Duration of hyoid maximum elevation	From hyoid first maximum elevation to hyoid last maximum elevation.
DOHMAE	Duration of hyoid max anter excursion	From first frame showing maximum anterior hyoid movement to last frame showing maximum anterior hyoid movement.
DOOUES	Duration of UES Open	From the time UES opens to the time UES closes
		OTHER MEASURES ANALYZED
OTD	Oral transit duration	Beginning of posterior movement of the bolus to the bolus head at ramus of mandible.
PTD	Pharyngeal transit duration	From bolus head at ramus of mandible to bolus head entering cricopharyngeus.
TSD	Total swallow duration	Beginning of posterior movement of the bolus to hyoid return to rest
STD 1	Stage transition duration	From bolus head at ramus of mandible to initiation of maximal hyoid excursion.
STD 2	Stage transition duration 2	From first barium at ramus of mandible to initiation of maximal hyoid excursion.
PRD	Pharyngeal response duration	From initiation of maximum hyoid excursion to hyoid return to rest.
DTOUES	Duration to open UES	From beginning of posterior bolus movement to UES opening.

Table 3

Primary duration measures at 1 and 2 weeks post-treatment and 1 and 2 weeks post-no treatment compared with pre-treatment. t value, degrees of freedom, & significance for each week.

Duration Measure	Mean Pre-Treatment	Mean 1 Week Treatment	Mean 2 Weeks Treatment	Mean 1 Week No Treatment	Mean 2 Weeks No Treatment
DOHME	.213	.196 $t(192)=.808$ $p = .952$	.233 $t(142)=-.108$ $p = .011$	.212 $t(189)=-1.12$ $p = .918$	.210 $t(180)=-.6684$ $p = .242$
DOHMAE	.222	.223 $t(188)=-.072$ $p = .507$	.250 $t(148)=-.543$ $p = .009$	.227 $t(183)=-.568$ $p = .668$	.220 $t(174)=.115$ $p = .172$
DOUESO	.592	.606 $t(177)=-.607$ $p = .351$	.614 $t(159)=-1.150$ $p=.472$	.581 $t(179)=.578$ $p = .236$	.589 $t(177)=-.724$ $p=.550$

DOHME – Duration of Hyoid Maximum Elevation; DOHMAE – Duration of Hyoid Maximum Anterior Excursion; DOOUES – Duration of Upper Esophageal Sphincter Opening.

Table 4

Means for all other measures at study initiation and after 2 weeks of treatment and 2 weeks of no-treatment.

Measure	Mean Study Initiation	Mean Post No-Treatment	Mean Post Treatment
Oral Transit	.569	.693	.604
Stage Transition 1	.843	.706	.734
Stage Transition 2	.826	.587	.642
Pharyngeal Transit	.987	.763	.887
Pharyngeal Response	**.895**	**.833**	**.911**
To UES Open	1.88	1.47	1.41
Penetration/Aspiration	3.13	2.30	2.99
Vallecular Residue	1.21	.83	1.10
Pyriform Residue	.90	.65	.73
DOSS	3.92	4.61	4.49

UES = Upper esophageal Sphincter; DOSS = Dysphagia Outcome Severity Scale

Pharyngeal Response Duration trended with primary measures of DOHME and DOHMAE.