METHODOLOGY

DYSPHAGIA

The Impact of EMG Biofeedback-Guided Effortful Swallows and Mendelsohn Maneuvers on Neurogenic Dysphagia Rehabilitation

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Background

The research literature reports a few case series studies in which swallowing therapy utilizing surface EMG biofeedback has led to positive treatment outcomes for patients with chronic (treatment refractory) swallowing difficulties post stroke. Additionally, the literature reports that surface EMG biofeedback is useful for teaching the correct performance of two specific swallowing therapy maneuvers: the Effortful Swallow (indicated when food or liquid is only partially cleared from the throat after a single swallowing attempt) and the Mendelsohn Maneuver (indicated when the upper esophageal sphincter does not open fully during a swallow attempt, resulting in incomplete clearance of food or liquid from the throat to the esophagus).

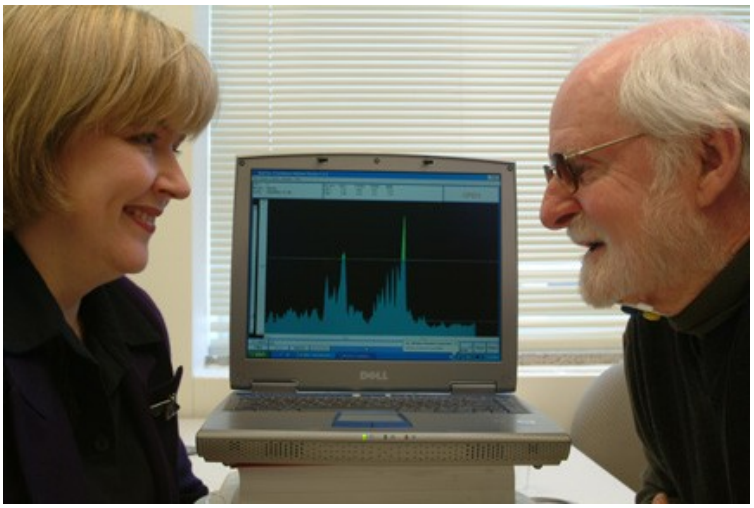

Figure 1— Dr. Steele with patient.

To date, research has not explored whether biofeedback can assist patients to enjoy earlier recovery of swallowing function when the problem is of recent onset (less than 6 months) related to a stroke or acquired brain injury. There is reason to expect that the technique can be beneficial early in the course of these injuries in cases where the Effortful Swallow and Mendelsohn Maneuver are appropriate.

Instrumentation

Surface electromyography (sEMG) is a technique for measuring the timing and amplitude of muscle contraction via electrodes placed on the skin surface. This technique can be used to provide visual biofeedback on a computer screen during swallowing therapy, by displaying a signal representing

the activity of the collective suprahyoid muscles (mylohyoid, geniohyoid, genioglossus, anterior belly digastric) during swallowing. An adhesive triode electrode patch is attached under the participant's chin with the positive and negative electrodes in midline, positioned just anterior to the hyoid bone (Fig. 2). The reference (ground) electrode is positioned laterally. The electrodes are attached to an EMG device (MyoTrac Infiniti, Thought Technology, Montreal) using a sensor cable and the signal from the device is registered on a computer using specialized software (BioGraph Infiniti, Thought Technology, Montreal).

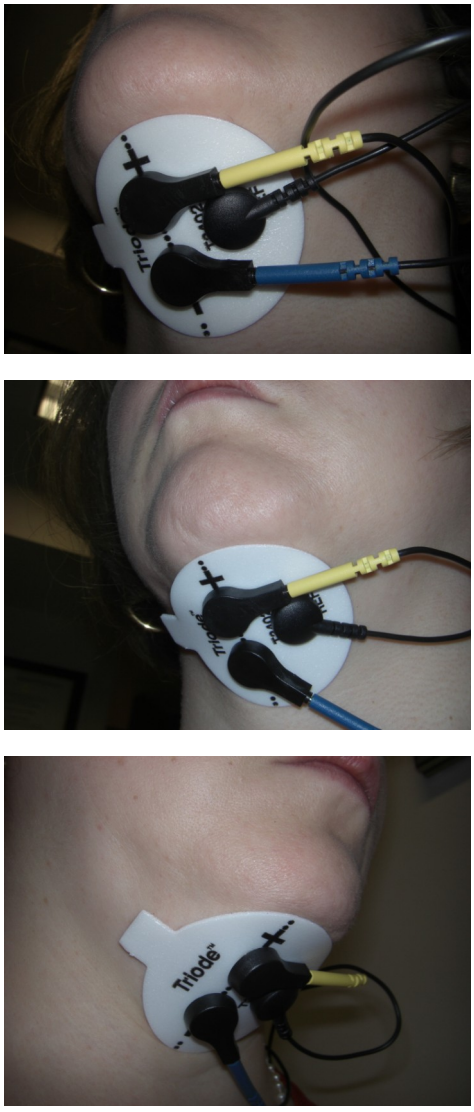

Figure 2— Electrode placement.

Treatment Method

We have designed a standardized dysphagia treatment protocol involving Effortful Swallows and Mendelsohn Maneuvers for patients who present with radiographically confirmed pharyngeal residue (i.e., incomplete clearance of food or liquid from the throat during swallowing) related to a recent stroke or acquired brain injury (not more than 6 months prior to enrollment in this study). We suggest that participants should receive 20 sessions of therapy, scheduled twice weekly, in which the selected maneuvers are practiced using surface EMG biofeedback. Outcomes should be measured using a standardized videofluoroscopic swallowing study. In particular, the outcomes that we expect following this treatment protocol are improvements in the range of hyolaryngeal excursion and a reduction in the severity of pharyngeal residues.

We recommend that a treatment session should include 60 swallows, practiced in 12 sets of 5 swallows. The protocol involves a progression of tasks from "regular effort saliva swallows" to "effortful saliva swallows" and "Mendelsohn Maneuver saliva swallows". Specialized software has been developed to lead the clinician through the treatment protocol in a prescribed order (BioGraph Infiniti, Thought Technology, Montreal).

Step 1 in the protocol is a check of the submental sEMG signal to make sure that the electrodes are correctly displaying activity of the floor of mouth musculature.

Once the electrodes have been positioned and connected, the clinician should ask the patient to perform some tasks that are expected to display variations in signal amplitude of the submental muscles. One easy task to confirm signal quality is to ask the patient to open and close their jaw repeatedly. Whenever the jaw opens, the submental sEMG signal should deflect in a positive direction. As the jaw closes, the signal should return to baseline. Larger jaw openings should elicit greater changes in signal amplitude.

Step 2 in the protocol involves a baseline measurement of sEMG amplitude during regular-effort saliva swallows.

For this task, we recommend that the patient to produce one saliva swallow every 30 seconds. The

Infiniti software will display a 30-second window on the computer. For the first 20 seconds, the patient's goal is to relax their face, mouth and throat muscles. If they do this successfully, the sEMG signal should move across the bottom of the screen at very low amplitude. The software provides an optional reward for maintaining the signal amplitude below 10 microVolts in the form of pleasant music. Some patients have difficulty achieving relaxation in this phase, and this can become a first treatment goal. If the signal amplitude is very high or very erratic, then this may suggest poor electrode contact and you may want to check your set-up. After 20 seconds of rest, the signal will cross a line on the screen where the written command "Swallow" is displayed. A vocal prompt will also be heard. Upon hearing this cue, the patient should perform a single saliva swallow within the 10 seconds that remain on the screen. If the patient has extreme difficulty initiating a saliva swallow, then a very tiny amount of water may be taken to provide a stimulus. After the swallow has occurred, the patient should return to the rest position. This 30-second sequence of resting and swallowing will be repeated 4 more times so that you can measure the patient's average swallow amplitudes for that day. Upon completion of the task, the software will provide a statistics output chart reporting the mean amplitude of the rest periods and of the 5 swallow peaks in the task. Additionally, fractional relative amplitudes will be automatically calculated so that you can use these in the remaining therapy tasks in the session.

Step 3 in the treatment protocol involves the practice of regular effort saliva swallows.

This task is optional if your patient has already developed the ability to reliably repeat saliva swallows within their regular effort range. However, if they are having difficulty doing so, this task should be practiced. The protocol proceeds in a similar manner to the previous baseline task, with alternating periods of 20-second-long rests and 10-second intervals in which a saliva swallow should be produced. In contrast to the previous task, however, this step in the protocol involves establishing a target amplitude for the peaks of each swallow. You can set this target between 80% and 100% of the mean peak amplitude measured in the baseline task, and a target line will appear on the screen. As the patient swallows, they should squeeze their swallowing muscles hard enough so that the signal approaches and reaches the target line. Success on this task will be defined as a mean peak amplitude within 10% of target across a series of 5 repeated saliva swallows.

Step 4 in the treatment protocol involves the practice of effortful saliva swallows.

Here the goal is to contract the swallowing muscles with greater effort so that the signal amplitude reaches higher values. Pushing the tongue harder into the palate (roof of the mouth) at the beginning of the swallow will help to achieve this goal. As with the previous task, you can set a target amplitude for each series of saliva swallows. We suggest that you begin working at 110% of the mean peak amplitude measured in the baseline reference task. Once your patient can produce swallows within 10% of this target on two successive series of 5 saliva swallows, you can increase the difficulty. We recommend increasing the difficulty in steps of 10%. We suggest that a typical swallowing treatment session include 20-35 swallows (4 to 7 sets of 5 swallows) of target amplitude swallow practice (either regular effort target amplitudes or effortful swallows).

Step 5 in the treatment protocol is practice of the Mendelsohn Maneuver.

This task is quite difficult for some patients and you may not be ready to introduce it until they have mastered effortful swallows. The goal of the Mendelsohn Maneuver is to prolong the muscle contraction associated with swallowing. It is very important that the event begins with a real swal-

low, leading into a sustained muscle contraction. The EMG pattern displayed on the screen will typically look like a "straight-backed chair", where the signal reaches a typical swallowing peak, then drops slightly, and is then maintained for 2-3 seconds. (Fig 3). For this task, you need to enter the 30% reference amplitude into the software, so that the software can count the duration of time that the patient manages to maintain contraction above this level. When the swallow command appears on screen, the patient should produce a saliva swallow and then hold the muscle contraction on (and above 30%) for 2-3 seconds. This is again repeated 5 times. We recommend that your treatment session should include at least 2 sets of this task.

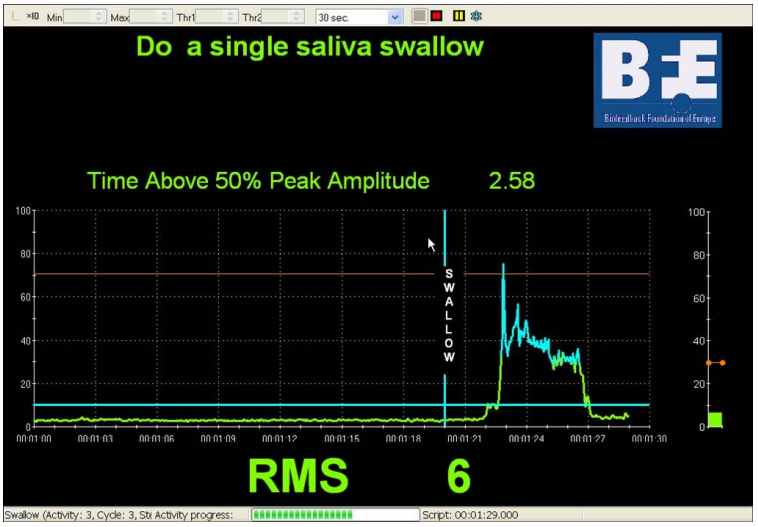

Figure 3— Appearance of Mendelsohn maneuver on screen.

As an option, some clinicians may choose to include some swallows of real food at the end of the treatment session. For this task, we recommend choosing a spoon-thick stimulus such as smooth yogurt or pudding. We recommend that the patient take a ½ teaspoon amount of this food and try to perform two strong swallows with that ½ teaspoon bolus. Then, we recommend that you instruct the patient to expectorate the remaining material from their throats into a spittoon. It is likely that there will be material to expectorate initially. As treatment progresses, this amount may become less. We recommend that you give only a few boluses in a treatment session and that patients who are including stimulus swallows in their sessions should be closely monitored for signs of aspiration and any respiratory consequences.

Outcome Data Collection Protocol

Treatment outcomes (i.e., changes in swallowing function) cannot be measured directly from the surface EMG equipment and need to be measured using a standardized instrumental exam, ideally a videofluoroscopic swallowing study (VFS). We recommend that treatment outcomes be measured after 20 sessions of therapy. VFS is a radiographic procedure for imaging the oropharynx during swallowing. Stimuli mixed with radio-opaque contrast media (i.e., 40% w/v barium suspensions) are administered, and a digitized video recording is captured from the x-ray with a temporal resolution of 30 frames per second. We recommend that this test should proceed according to a standardized protocol [7]. For the purposes of monitoring treatment outcomes, we recommend that you compare swallowing physiology from 2-4 discrete teaspoon-sized boluses of thin liquid barium suspension and 2-4 discrete teaspoon-sized boluses of a spoon-thick stimulus. The specific features that we recommend you compare are: excursion of the hyolaryngeal complex, lateral diameter of upper esophageal sphincter opening, and the presence of residues in the vallecular space or pyriform sinus after the swallow.

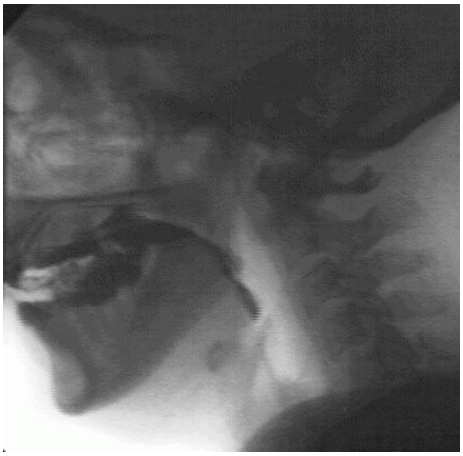

Figure 4— Videofluoroscopy.

How is EMG biofeedback useful for teaching the Effortful Swallow and the Mendelsohn Maneuver?

The muscles that move the hyolaryngeal complex during swallowing are located in the floor of mouth, just beneath the tongue. The activity of these muscles can be measured using surface EMG electrodes placed under the chin. By displaying a signal that represents the activity of these muscles on a screen, patients can watch these muscles contract and can learn to perform higher amplitude contractions (the Effortful Swallow) or sustained contractions (the Mendelsohn Maneuver).

What are the norms for sEMG amplitude during swallowing?

It is not possible to talk about norms for EMG amplitude of the submental muscles during swallowing. First of all, the signal that is collected from electrodes positioned underneath the chin includes composite information about several muscles (the mylohyoid, geniohyoid, anterior belly of digastric and genioglossus). Unless you can be absolutely certain that you have placed the electrodes in precisely the same location across different therapy sessions, you cannot be certain that the EMG signal amplitude range will be the same. Secondly, any tissue between the surface of the skin and the underlying muscles will dampen the signal. Because different people have different degrees of tissue or fat in their necks, EMG signal amplitudes can vary widely across individuals.

How can you tell if a patient is improving using sEMG biofeedback?

Surface EMG captures and represents only one aspect of swallowing, namely the activity of the muscles under the chin. Consequently, you cannot be certain (based on the sEMG signal alone) whether a patient's swallowing has improved. This needs to be confirmed, instead, using an instrumental swallowing assessment such as videofluoroscopy. We strongly advise that you should not do swallowing therapy using sEMG biofeedback unless you are in a position to measure the effectiveness of your treatment using an instrumental swallowing assessment procedure. It is not possible to interpret the sEMG signal directly to determine whether or not swallowing has improved.

If your patient is unable to swallow at the beginning of treatment, then you may notice some clinical changes as treatment proceeds. Initially, it is quite likely that this kind of patient (frequently someone who has had a brainstem stroke) will spit their saliva and secretions out of their mouth on a regular basis. This is because they are unable to swallow their saliva. As treatment progresses, your patient may recover the ability to swallow their saliva. They may report that they need to spit their secretions out less frequently, and they may report that their sleep patterns are less disturbed, because they need to wake less frequently to clear secretions.

If you are including trial swallows of food (usually a smooth pudding-thick stimulus like yogurt) in your treatment sessions, then it is possible that the patient will begin to be able to swallow this material. You should be very careful to take clinical notes documenting any changes in the patient's clinical signs and symptoms across the course of therapy. If any of the material that the patient eats is aspirated (enters the airway) then this increases the risk that they will develop pneumonia. If the patient develops chest congestion or a wet voice, you should be very cautious and should stop giving real food trials in therapy. A doctor should evaluate the patient in this situation to make sure they are not developing a chest infection.

Risks and Benefits

Risks: There are no known risks involved for patients receiving this treatment protocol.
Benefits: Participants may benefit directly from this treatment protocol with improvements in their

swallowing function. This cannot, however, be guaranteed.

Practitioner Training

Licensed health professionals that are thinking about getting started right away in this exciting field can purchase a software suite with documentation to support the techniques necessary for using surface electromyography for dysphagia rehabilitation.

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