MICHIGAN SPEECH LANGUAGE HEARING ASSOCIATION

2021 MSHA Annual Conference ● March 18-20, 2021 ● VIRTUAL CONFERENCE

Propelling the Professions into the Future: Connecting Research & Clinical Practice

Current and Future Directions in Swallowing Assessment and Treatment: Standardized Protocols and Cross-System Approaches

PART I

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Swallowing Cross-Systems Collaborative

Northwestern University

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Support & Disclosures

- Principal Investigator, VA RR&D, 1I01RX002352-01A1, Clinical Impact of Respiratory Swallow Training on Refractory Dysphagia in OP HNC, 2018-2022
- Principal Investigator, NIH/NIDCD, 2K24DC12801-07, Data Science Applications in Communication and Swallowing Disorders, 2020-2024
- Co-Investigator (Principal Investigator: Shuai Xu, MD) NIH/STTR, R41AG062023-01, A Therapeutic Wearable Sensor for Dysphagia, 2018-2022
- Co-Investigator (Principal Investigator: Heather Bonilha, PhD), NIH/NIDDK R01DK122975-01, Excess Radiation Exposure in Infants and Children from Videofluoroscopic Swallow Studies
- Machine Vision Fellowship Grant, Bracco Diagnostics, Inc., 2019-2021
- Copyright royalties from Northern Speech Services through agreement with Medical University of South Carolina
- U.S. provisional patent; Feb 16, 2018: US 62/710,324. Inventors: Shuai Xu , Kun Lee, Angela Roberts, Bonnie Martin-Harris, John Rogers.
- Salary from Northwestern University
- Salary from Edward Hines, Jr. VA Hospital

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Morning Session Agenda

- 8:30 – 8:45 Opening Remarks and Introductions
- 8:45 – 9:15 Standardization and Personalized Patient Care: Essential and Noncompeting Elements of Clinical Practice
- 9:15 – 9:45 Overview of Swallowing Assessment: Reproducibility, Validity & Clinical Feasibility of Protocols & Measures
- 9:45 – 10:15 Nature & Severity of Impaired Swallowing Function: Swallowing Safety, Swallowing Efficiency and Physiology
- 10:15 – 10:30 BREAK
- 10:30 – 11:00 Targeted Therapies Derived from Standardized Assessments: Frontline Tactics, Compensation, Adaptation
- 11:00 – 11:30 Targeted Therapies Derived from Standardized Assessments: Strengthening, Skill, Assistive Technology
- 11:30 – 11:45 Questions and Discussion

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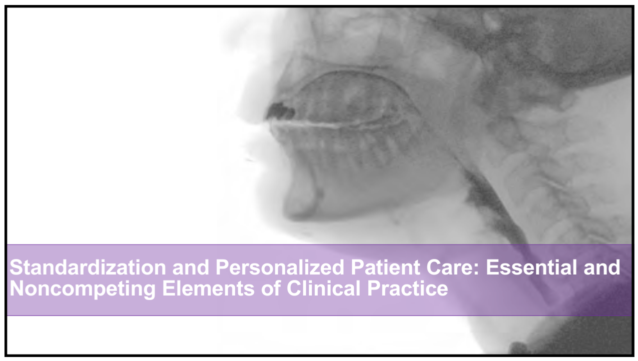

Standardization and Personalized Patient Care: Essential and Noncompeting Elements of Clinical Practice

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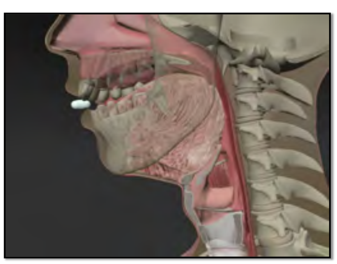
Normal Swallow



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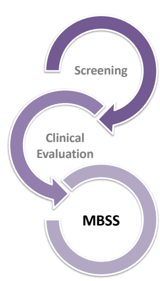
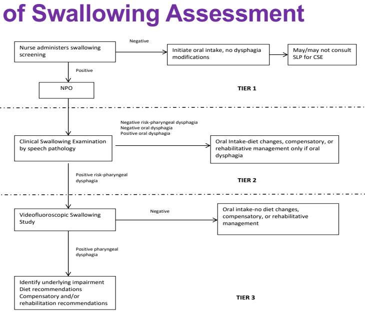
Levels of Swallowing Assessment





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Daniels, Martino, Silverman, & Suiter, 2018

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Screening of Swallowing: Purpose?

☑ Is the patient dysphagic?

☒ What is the nature of the patient's physiology during swallowing?

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Screening Tool Defined

Purpose → Probable dysphagia

Clinical Criteria	Statistical Criteria
Non-invasive Non-technical Administered by a non-expert Results quickly interpretable	Sensitivity > 90%
Eddy, et al. 1991.	*Swets, et al. 1992.*

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What is a Clinical Swallow Examination (CSE)?

- ***Indirectly*** observe swallowing function in a "natural" setting
- **Non-instrumental**
- Easily repeatable
- Readily available
- Inexpensive
- Completed by SLP

Swallow Screen ≠ CSE

Some argue that clinical assessments are in fact, screening measures, since they do not elucidate the pathophysiology contributing to the swallowing impairment(s)

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Limitations of CSE

- ***Cannot***...
  - Determine underlying impairment of swallowing
  - Confirm or rule out presence of airway invasion
  - Identify effects of compensatory strategies
  - Recommend appropriate *targeted* approaches to treatment

"The cost of false positives may be financially high, but the costs of false negatives can be life-threatening."
~Dr. Gary McCullough

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Prior to Instrumental

Cranial Nerve (CN) Exam

- **Speech, Language, Cognition**
  - CN V, VII, IX, X, XI, and XII
  - Sensation, range of motion, speed, symmetry, accuracy, and strength (against resistance)
- **Motor Speech Exam**
  - Respiration, phonation, articulation, resonance, prosody, and intelligibility
- **Reflexes**
  - Cough, gag

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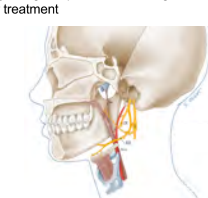
Modified Barium Swallow Study

Surrogate information regarding the sensorimotor function that underpins physiologic impairment and targets for treatment



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Modified Barium Swallow Study

- Identify and distinguish the presence, type and estimated severity of physiologic swallowing impairment
- Detail the effects of selected front-line interventions (postures, maneuvers, bolus variables) on swallowing physiology, airway protection and efficiency.
- Develop intake (oral, tube etc.) and diet texture/nutritional management plans in collaboration with the physician and interdisciplinary team

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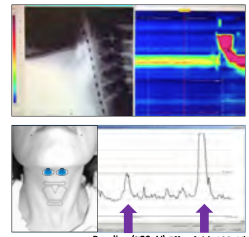
Targeted Intervention

EFFORTFUL SWALLOW

Indications/Rationale for use:

- Reduced ***tongue base retraction***
  - Shields laryngeal inlet
- Reduced pharyngeal stripping
- Decreased pharyngeal contraction
  - Effort increase ***posterior tongue base*** and pharyngeal movement)



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Pouderour & Kahrilas, 1995; Takasaki et al., 2011; Hoffman et al., 2012

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Post Instrumental

- Clinical Validation

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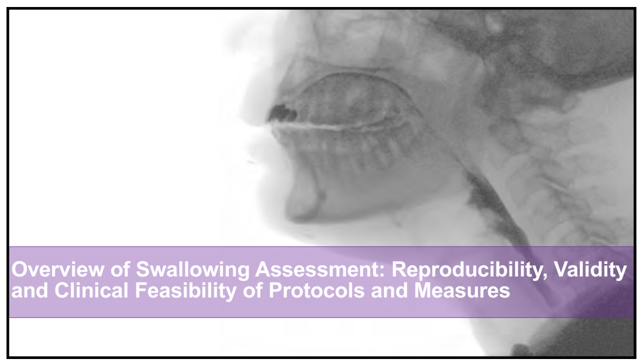

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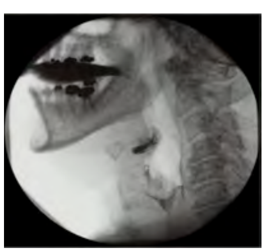
BEYOND Residue and Aspiration – Signs of Risk



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Risk Identification vs. Detailed Mechanism(s)


Chest X-ray


MRI

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Penetration Aspiration Scale

Table 2. Final version of the 8-Point Penetration-Aspiration Scale

1. Material does not enter the airway
2. Material enters the airway, remains above the vocal folds, and is ejected from the airway
3. Material enters the airway, remains above the vocal folds, and is not ejected from the airway
4. Material enters the airway, contacts the vocal folds, and is ejected from the airway
5. Material enters the airway, contacts the vocal folds, and is not ejected from the airway
6. Material enters the airway, passes below the vocal folds and is ejected into the larynx or out of the airway
7. Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort
8. Material enters the airway, passes below the vocal folds, and no effort is made to eject

Penetration (2–5)

Aspiration (6–8)

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Rosenbek, J., Robbins, J., Roecker, E., Coyle, J., & Wood, J. (1996). A penetration-aspiration scale. *Dysphagia*, 11(2), 93-98.

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Residue Scales

- Binary (presence or absence) Ekberg et al., 1992; Perlman et al., 1992; Rao et al., 2003; Clave et al., 2006
- Categorical (location) Dejaeger et al., 1997; Omari et al., 2011
- Estimates (amount) Pauloski et al., 2002; Logemann et al., 1989 & 2005
- Ordinal Scales Robbins et al., 2007; Hind et al., 2001; Rosenbek et al., 1996; Martin-Harris et al., 2008
- Semiquantification (grades of severity) Han et al., 2001; Eisenhuber et al., 2002; Ryu et al., 2012
- Vallecular Residue Ratio Scale (VRRS) Dyer, Leslie & Drinnan, 2009
- Normalized Residue Ratio Scale (NRRS) Pearson et al., 2013

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Residue Scales

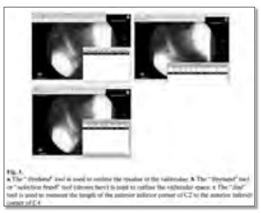
Location – Dejaeger et al., 1997

No retention: no barium remaining in the valleculae and in the piriform sinuses with the exception of minimal coating of our probe
Retention in the valleculae: barium remaining in one or both of the vallecular spaces after the swallow
Retention in the piriform sinuses: barium remaining in one or both of the piriform sinuses after the swallow
Diffuse pharyngeal retention which is defined as retention in the valleculae and in the piriform sinuses

Ordinal Scale – MBSImP, Martin-Harris et al., 2008

Component 16 – Pharyngeal Residue
Judge after first swallow or after the last swallow of the sequential swallow task
0 = Complete pharyngeal clearance
1 = Trace residue within or on pharyngeal structures
2 = Collection of residue within or on pharyngeal structures
3 = Majority of contrast within or on pharyngeal structures
4 = Minimal to no pharyngeal clearance

Normalized Residue Ratio Scale – Pearson et al., 2013



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DIGEST – Risk Identification/Toxicity

NCI Common Terminology Criteria for Adverse Events

Original Article

Dynamic Imaging Grade of Swallowing Toxicity (DIGEST): Scale Development and Validation

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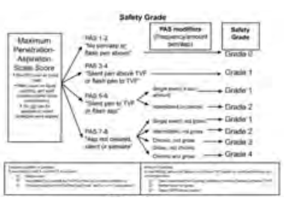
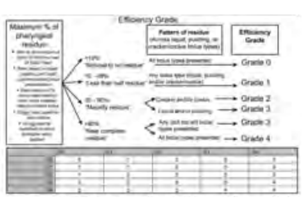
DIGEST





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Hutcheson et al., 2016

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PAS Levels

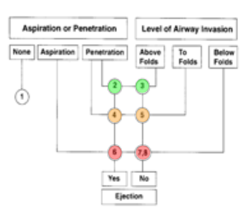
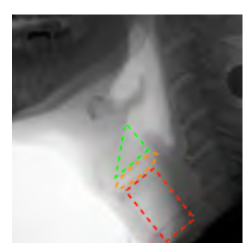


Fig. 1. Schematic representation of the Penetration-Aspiration Scale.



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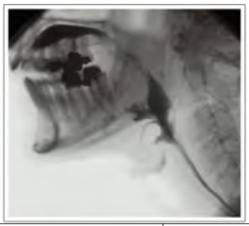
Secondary Effect → Physiology



PAS Scale	(8) Below VF, no effort to eject	(8) Below VF, no effort to eject
Oral Residue	Present	Present
Pharyngeal Residue	Present	Present

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Secondary Effect → Physiology

PAS Scale	(8) Below VF, no effort to eject	(8) Below VF, no effort to eject
5 – Oral Residue	(3) Majority of contrast remaining	(2) Residue collection on oral structures
16 – Pharyngeal Residue	(3) Majority of contrast remaining	(4) Minimal to no pharyngeal clearance
6 – Initiation of the Pharyngeal Swallow	(0) Bolus head at posterior angle ramus	(4) No visible initiation
8 – Laryngeal Elevation	(1) Partial superior mvmt thyroid cartilage	(3) No superior mvmt thyroid cartilage
10 – Epiglottic Inversion	(1) Partial inversion	(2) No inversion
11 – Laryngeal Vestibular Closure	(1) Incomplete; narrow column contrast	(2) None; wide column contrast in LV
12 – Pharyngeal Stripping Wave	(1) Present - diminished	(2) Absent
14 – PES Opening	(1) Partial distension/duration	(3) No distension; total obstruction
15 – Tongue Base Retraction	(3) Wide of contrast between TB and PW	(4) No visible posterior motion of TB

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*MBSImP components and score definitions

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PAS is an Extreme Score and not a Necessary Feature of Impairment

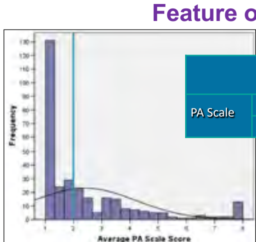

Fig. 4 Distribution of average PA Scale scores across subjects

		Oral Impairment	Pharyngeal Impairment
PA Scale	Correlation	.270	.200
	P-value	< .0005	< .0005

Penetration-Aspiration Scale

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Martin-Harris et al. 2008

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Standardized assessment of swallowing impairment,

NIH/NIDCD K23DC005764, 2003-2010

Standardized Assessment of Swallowing Impairment

NIH/NIDCD K23DC005764, 2003-2010

- **Valid** – content, construct, external
- **Reliable** – intra- and inter-rater
- **Physiologic** vs. symptom based
- **Clinically practical**
- Linked to **clinical action** – targeted therapy

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Why Standardize?

Standardized assessment of swallowing impairment

NIH/NIDCD K23DC005764, 2003-2010

Method of Training

Administration Protocol

Assessment Tool

Vernacular

Analysis and Reporting Methods

Transparency

Reproducibility

Outcomes

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MBSImP™ Standardized Protocol:

Viscosity, Volume, Dose, Method

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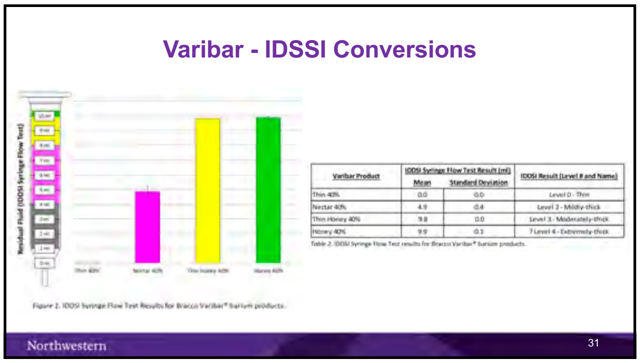

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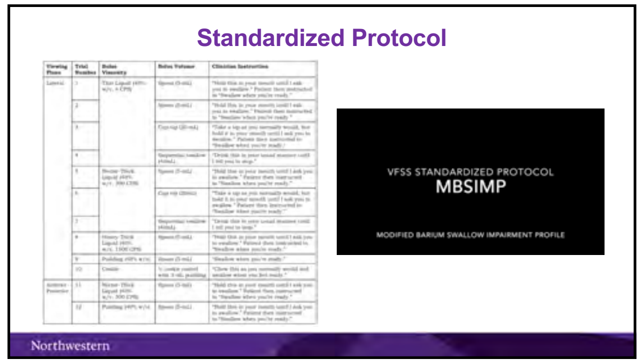

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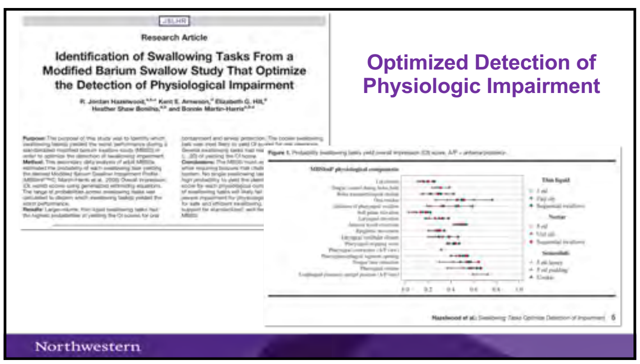

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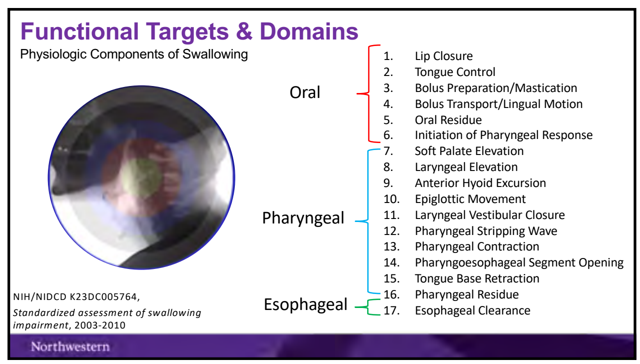

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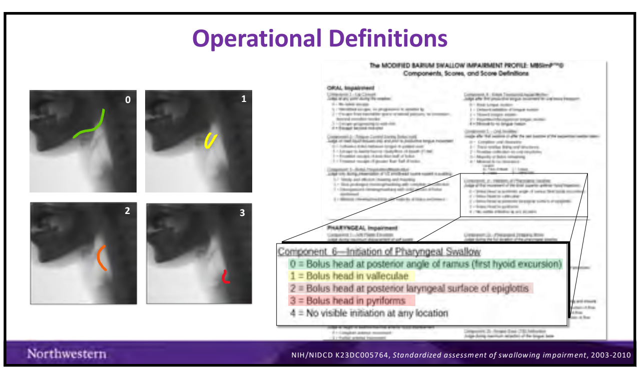

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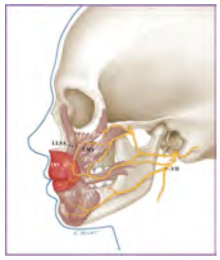
Component 1: Lip Closure

WHAT?
- Assesses patient's ability to seal the bolus within the anterior oral cavity

WHERE?
- The presence and location of contrast material seen between or outside the lips on the lateral view

WHEN?
- During any point of the swallow



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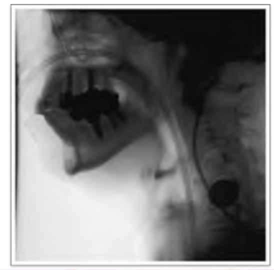
Component 1: Lip Closure

Component 1—Lip Closure
Judge at any point during the swallow.
0 = No labial escape
1 = Interlabial escape; no progression to anterior lip
2 = Escape from interlabial space or lateral juncture; no extension beyond vermilion border
3 = Escape progressing to mid-chin
4 = Escape beyond mid-chin



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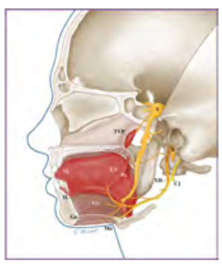
Component 2: Tongue Control During Bolus Hold

WHAT?
- Assesses patient's ability to seal the tongue to the hard and soft palate

WHERE?
- Oral cavity
- Tongue and palatal seal; anteriorly, posteriorly and laterally

WHEN?
- ***PRIOR*** to the initiation of productive tongue movement to propel the bolus



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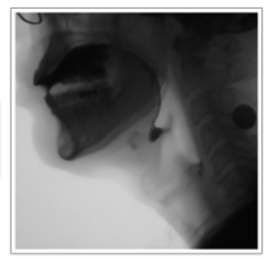
Component 2: Tongue Control During Bolus Hold

Component 2—Tongue Control During Bolus Hold
Judge on held liquid boluses only and prior to productive tongue movement
0 = Cohesive bolus between tongue to palatal seal
1 = Escape to lateral buccal cavity/floor of mouth (FOM)
2 = Posterior escape of less than half of bolus
3 = Posterior escape of greater than half of bolus



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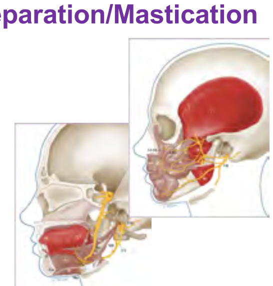
Component 3: Bolus Preparation/Mastication

WHAT?
- Assesses efficiency of chewing
- Ability of the patient to break down the solid for safe complete transport from the oral cavity
- Tongue movement is integrated into chewing

WHERE?
- Oral cavity

WHEN?
- During presentation of solid bolus



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Component 3: Bolus Preparation/Mastication

Component 3—Bolus Preparation/Mastication
Judge only during presentation of 1/2 shortbread cookie coated in pudding
0 = Timely and efficient chewing and mashing
1 = Slow prolonged chewing/mashing with complete re-collection
2 = Disorganized chewing/mashing with solid pieces of bolus unchewed
3 = Minimal chewing/mashing with majority of bolus unchewed

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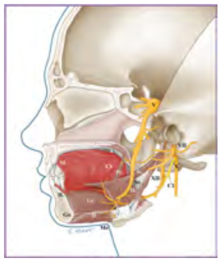
Component 4: Bolus Transport/Lingual Motion

WHAT?
- Characterizes the pattern of lingual movement and bolus transport through the oral cavity

WHERE?
- Oral cavity, oral tongue
- All bolus types

WHEN?
- AFTER the initial gesture toward productive tongue movement for oral bolus transport



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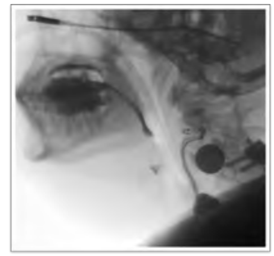
Component 4: Bolus Transport/Lingual Motion

Component 4—Bolus Transport/Lingual Motion
Judge after first productive tongue movement for oral bolus transport
0 = Brisk tongue motion
1 = Delayed initiation of tongue motion
2 = Slowed tongue motion
3 = Repetitive/disorganized tongue motion
4 = Minimal to no tongue motion



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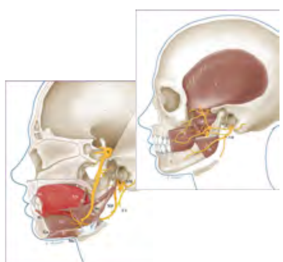
Component 5: Oral Residue

WHAT?
- Clinical sign of physiologic impairment
- Contrast material remaining in the oral cavity

WHERE?
- Oral cavity

WHEN?
- After completion of the first swallow, *or*
- Following the last swallow of the sequential swallowing task



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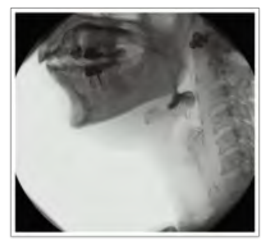
Component 5: Oral Residue

Component 5 – Oral Residue
Judge after first swallow or after the last swallow of the sequential swallow
0 = Complete oral clearance
1 = Trace residue lining oral structures
2 = Residue collection on oral structures
3 = Majority of bolus remaining
4 = Minimal to no clearance



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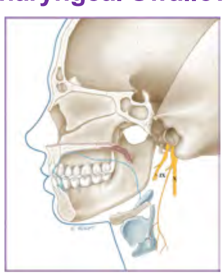
Component 6: Initiation of Pharyngeal Swallow

WHAT?
- Pharyngeal response to sensory inputs including bolus characteristics and movement of the tongue

WHERE?
- Position of the bolus head, or leading edge

WHEN?
- First initiation of the pharyngeal swallow represented by the ***first movement of the brisk superior-anterior hyoid trajectory***



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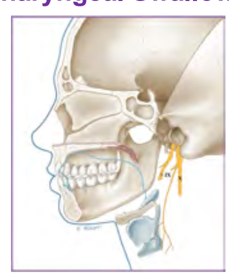
Component 6: Initiation of Pharyngeal Swallow

The act of swallowing is a synergistic motor response to stimulation of afferent receptors (CN IX, CN X)

- Oropharynx
- Supraglottis
- Glottis
- Pyriform sinuses



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Component 6: Initiation of Pharyngeal Swallow

Component 6—Initiation of Pharyngeal Swallow

Judge at first movement of the brisk superior-anterior hyoid trajectory

- 0 = Bolus head at posterior angle of ramus (first hyoid excursion)
- 1 = Bolus head in valleculae
- 2 = Bolus head at posterior laryngeal surface of epiglottis
- ▶ 3 = Bolus head in pyriforms
- 4 = No visible initiation at any location

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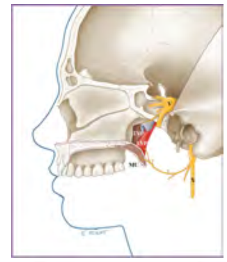
Component 7: Soft palate elevation

WHAT?
- Soft palate to pharyngeal wall contact is based on the presence of ***contrast or air*** between the two structures

WHERE?
- Contact of the soft palate and posterior pharyngeal wall as viewed on the lateral viewing plane

WHEN?
- At the height or maximum displacement of the soft palate



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Component 7: Soft Palate Elevation

Component 7—Soft Palate Elevation

Judge during maximum displacement of soft palate.

- 0 = No bolus between soft palate (SP)/pharyngeal wall (PW)
- 1 = Trace column of contrast or air between SP and PW
- ▶ 2 = Escape to nasopharynx
- 3 = Escape to nasal cavity
- 4 = Escape to nostril with/without emission

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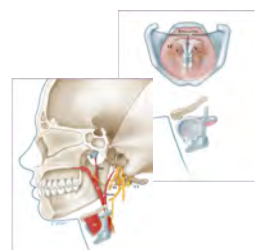
Component 8: Laryngeal Elevation

WHAT?
- Elevation of the larynx accomplished by contraction of the thyrohyoid muscle and pharyngeal shortening

WHERE?
- Approximation of the forwardly displaced arytenoid cartilages to the posteriorly displaced epiglottic petiole

WHEN?
- At the time the epiglottis reaches its MOST horizontal position



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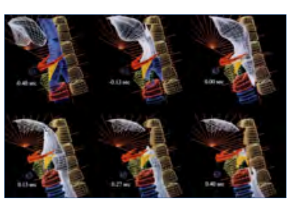
Component 8: Laryngeal Elevation

Laryngeal Elevation Facilitated by Pharyngeal Shortening

Pharynx

Fibromuscular tube

- External layer
  - Superior constrictor
  - Middle constrictor
  - Inferior constrictor
- Internal layer
  - Stylopharyngeus (levator)
  - Palatopharyngeus (levator)
  - Salpingopharyngeus



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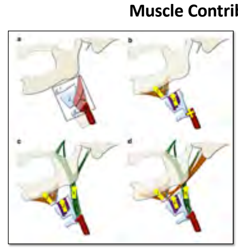
Component 8: Laryngeal Elevation

Muscle Contributions to Laryngeal Elevation



1) **Current theory** of hyolaryngeal elevation (submental and thyrohyoid muscles)

2) **2-sling theory**
- Anterior
  - Submental muscles
- Posterior
  - Long pharyngeal muscles
  - Thyrohyoid

3) **2-sling theory revised**
- Suprahyoid muscle group as anterior sling

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Component 8: Laryngeal Elevation

- Both submental and long pharyngeal muscles demonstrate greater potential to elevate the hyolaryngeal complex than the thyrohyoid
- Suprahyoid muscles demonstrate the greatest force for hyolaryngeal elevation
- Long pharyngeal muscles have similar potential to contribute to hyolaryngeal elevation
- *Contribution to PESO?*

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Component 8: Laryngeal Elevation

Component 8—Laryngeal Elevation
Judge when epiglottis is in its most horizontal position.
0 = Complete superior movement of thyroid cartilage with complete approximation of arytenoids to epiglottic petiole
1 = Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole
2 = Minimal superior movement of thyroid cartilage with minimal approximation of arytenoids to epiglottic petiole
3 = No superior movement of thyroid cartilage

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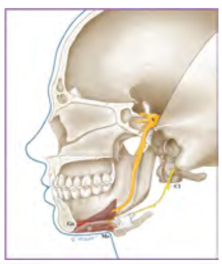
Component 9: Anterior Hyoid Excursion

WHAT?
- Anterior displacement of the hyoid bone

WHERE?
- The angle of the thyroid cartilage relative to the position of the hyoid bone

WHEN?
- The height of the pharyngeal swallow
  - Maximal anterior displacement of the hyoid bone



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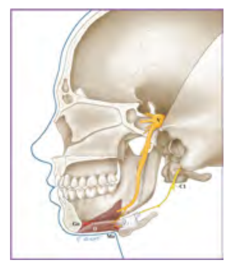
Component 9: Anterior Hyoid Excursion

- Facilitates airway closure and pharyngoesophageal segment opening
- Facilitates epiglottic inversion
  - Two-step movement of epiglottis (Ekberg & Sigurjonsson, 1982)



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Component 9: Anterior Hyoid Excursion

Component 9—Anterior Hyoid Excursion
Judge at height of swallow/maximal anterior hyoid displacement
0 = Complete anterior movement
1 = Partial anterior movement
2 = No anterior movement

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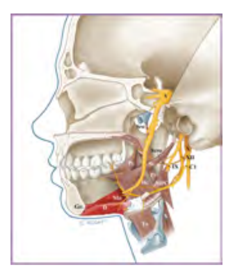
Component 10: Epiglottic Movement

WHAT?
- Laryngeal elevation and anterior traction of the hyolaryngeal complex resulting in inferior displacement of the epiglottis
- Facilitates maximal laryngeal vestibular closure

WHERE?
- The epiglottis is a rigid cartilage representing the uppermost structure of the larynx

WHEN?
- Height of the pharyngeal swallow
  - Maximal anterior displacement of the epiglottis



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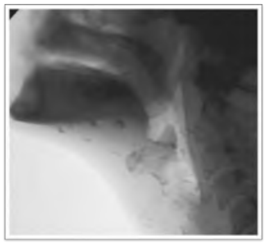
Component 10: Epiglottic Movement

Component 10–Epiglottic Movement
Judge at height of swallow/maximal anterior hyoid displacement
0 = Complete inversion
1 = Partial inversion
2 = No inversion



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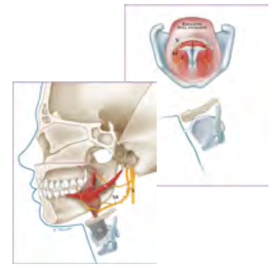
Component 11: Laryngeal Vestibular Closure

WHAT?
- Compression of supraglottic valves
- Late closure of the laryngeal vestibule
- Presence or absence of contrast material or air in the laryngeal inlet

WHERE?
- Laryngeal vestibule

WHEN?
- During late closure of the laryngeal vestibule
- Maximal anterior displacement of the hyoid



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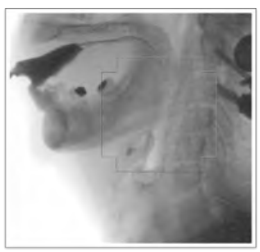
Component 11: Laryngeal Vestibular Closure

Component 11—Laryngeal Vestibular Closure
Judge at height of swallow/maximal anterior hyoid displacement.
0 = Complete; no air/contrast in laryngeal vestibule
1 = Incomplete; narrow column air/contrast in laryngeal vestibule
2 = None; wide column air/contrast in laryngeal vestibule



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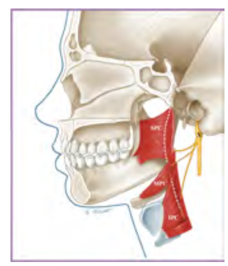
Component 12: Pharyngeal Stripping Wave

WHAT?
- Progressive contraction of the pharyngeal constrictors

WHERE?
- Full length of the posterior pharyngeal wall from the nasopharynx to the PES.

WHEN?
- Full duration of the pharyngeal swallow



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Component 12: Pharyngeal Stripping Wave

Component 12—Pharyngeal Stripping Wave
Judge during the full duration of the pharyngeal swallow.
0 = Present - complete
1 = Present - diminished
2 = Absent

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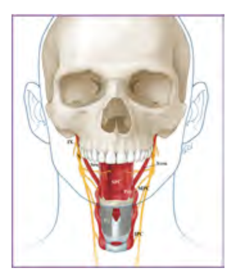
Component 13: Pharyngeal Contraction

WHAT?
- Represents a combination of pharyngeal shortening and stripping as viewed in the AP plane

WHERE?
- Focus on the ability of the lateral pharyngeal walls to efficiently shorten and compress against the tail of the bolus throughout the pharynx

WHEN?
- AP view only
- Observe the pharyngeal walls at rest and throughout maximum movement (shortening and inward compression)



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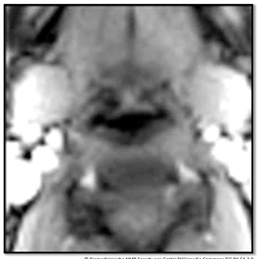
Pharyngeal Contraction

Fast Low-Angle Shot MRI (FLASH MRI)



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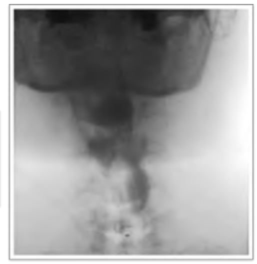
Component 13: Pharyngeal Contraction

Component 13—Pharyngeal Contraction
Judge in AP view at rest and throughout maximum movement
0 = Complete
1 = Incomplete (Pseudodiverticulae)
2 = Unilateral Bulging
3 = Bilateral Bulging



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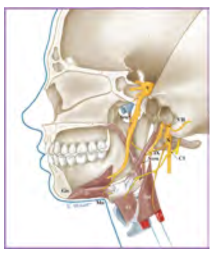
Component 14: PES Opening

WHAT?
- Distension and duration of pharyngoesophageal segment opening (PESO)

WHERE?
- Pharyngoesophageal segment (PES)
  - Cricopharyngeaus muscle (CPM)

WHEN?
- During maximum distension of PES through closure



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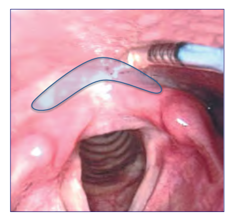
Component 14: PES Opening

WHAT?
- Distension and duration of pharyngoesophageal segment opening (PESO)

WHERE?
- Pharyngoesophageal segment (PES)
  - Cricopharyngeaus muscle (CPM)

WHEN?
- During maximum distension of PES through closure



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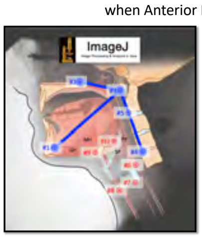
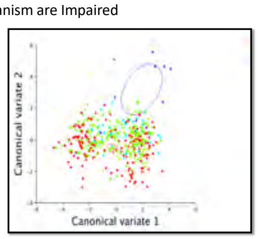
Pharyngeal Adaptation

William G. Pearson, Jr., PhD

Hypothesis: Pharyngeal Muscles Contribute to PES Opening when Anterior Mechanism are Impaired





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Pharyngeal Adaptation

Normal PES Opening Mechanism

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Pharyngeal Adaptation

Adaption PES Opening Mechanism

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Component 14: PES Opening

Component 14—Pharyngoesophageal Segment Opening
Judge during maximum distension of PES and throughout opening and closure
0 = Complete distension and complete duration; no obstruction of flow
1 = Partial distension/partial duration; partial obstruction of flow
2 = Minimal distension/minimal duration; marked obstruction of flow
3 = No distension with total obstruction of flow

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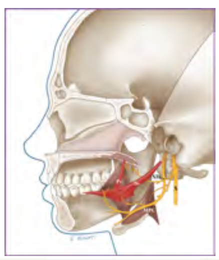
Component 15: Tongue Base Retraction

WHAT?
- Posterior retraction of the tongue resulting in approximation of the tongue base (TB) with the anteriorly displacing pharyngeal wall (PW)

WHERE?
- Presence and degree of bolus or air between the TB and PW

WHEN?
- During maximal retraction of the tongue
  - Maximum anterior movement



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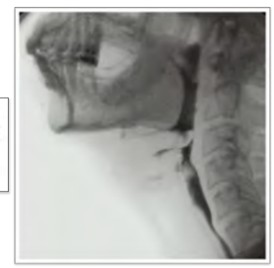
Component 15: Tongue Base Retraction

Component 15—Tongue Base (TB) Retraction
Judge during maximum retraction of the tongue base.
0 = No contrast between TB and posterior pharyngeal wall (PW)
1 = Trace column of contrast or air between TB and PW
2 = Narrow column of contrast or air between TB and PW
3 = Wide column of contrast or air between TB and PW
4 = No visible posterior motion of TB



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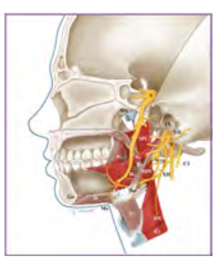
Component 16: Pharyngeal Residue

WHAT?
- Clinical sign of physiologic impairment
- Dependent on physiologic cause (pharyngeal contraction, tongue base retraction, PESO)
- Contrast material remaining in the pharynx

WHERE?
- Pharynx

WHEN?
- After completion of the first swallow, *or*
- Following the last swallow of the sequential swallowing task



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Component 16: Pharyngeal Residue

Component 16—Pharyngeal Residue
Judge after first swallow or after the last swallow of the sequential swallow
0 = Complete pharyngeal clearance
1 = Trace residue within or on pharyngeal structures
2 = Collection of residue within or on pharyngeal structures
3 = Majority of contrast within or on pharyngeal structures
4 = Minimal to no pharyngeal clearance

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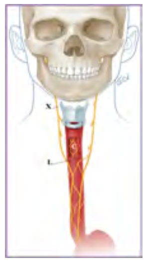
Component 17: Esophageal Clearance

WHAT?
- Esophageal clearance in the upright or semi-upright position
- Does NOT evaluate esophageal motility or structural abnormalities

WHERE?
- Esophagus – proximal to distal, through the lower esophageal segment (LES)

WHEN?
- During bolus transit through the oral cavity to the LES



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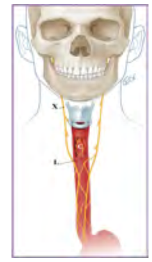
Component 17: Esophageal Clearance

- **Esophageal clearance in the upright position**
  - Lower esophageal sphincter relaxation
  - Esophageal contraction
  - Lower esophageal sphincter opening



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Gullung, J. L., Hill, E. G., Castell, D. O., & Martin-Harris, B.

Oropharyngeal and Esophageal Swallowing Impairments: Their Association and the Predictive Value of the MBSImP and Combined Multichannel Intraluminal Impedance—Esophageal Manometry.

Annals of Otology, Rhinology & Laryngology, 121(11), 738-745. (2012)


Oropharyngeal and esophageal swallowing impairments: Their association and the predictive value of the modified barium swallow impairment profile and combined multichannel intraluminal impedance-esophageal manometry

Abstract

EVELYN TRAMMELL INSTITUTE for Voice & Swallowing

MUSC MEDICAL UNIVERSITY of SOUTH CAROLINA

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Results-Associations

MBSImP internal associations:
- 82% of patients with abnormal esophageal clearance had delayed initiation of pharyngeal swallow
- Impairment of component 6 (initiation of pharyngeal swallow) and component 17 (esophageal clearance) ($p = 0.023$)
- Oral total scores and ($p = 0.039$) an MII-EM

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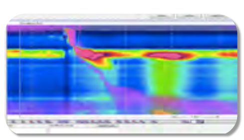
Results-Predictive Value

- 164 patients
- Impaired component 17 (EC) strongly associated with abnormal MII-EM results ($p < 0.001$)
  - 53/67 (79%) patients with abnormal MII-EM had impaired component 17
  - Sensitivity: 80%
  - Specificity: 48%



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Component 17: Esophageal Clearance

Component 17—Esophageal Clearance Upright Position
Judge in AP view during bolus transit through the oral cavity to the LES
0 = Complete clearance; esophageal coating
1 = Esophageal retention
2 = Esophageal retention with retrograde flow below pharyngo-esophageal segment (PES)
3 = Esophageal retention with retrograde flow through PES
4 = Minimal to no esophageal clearance

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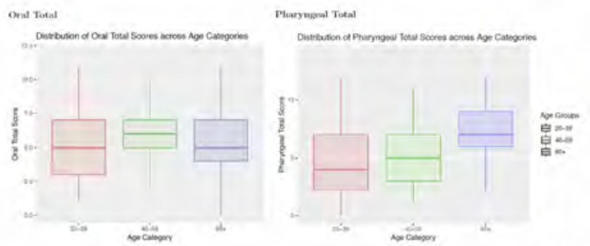
Normal Variation in Adult Swallows



Garand et al., unpublished data

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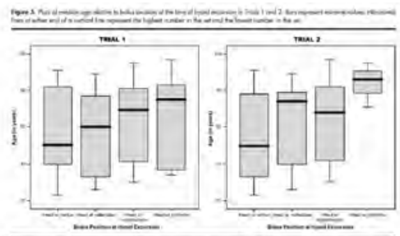
Normal Variation in Adult Swallows



Martin-Harris, B., Brodsky, M. B., Michel, Y., Lee, F. S., & Walters, B. (2007). Delayed initiation of the pharyngeal swallow: normal variability in adult swallows. *Journal of Speech, Language, and Hearing Research, 50*(3), 585-594.

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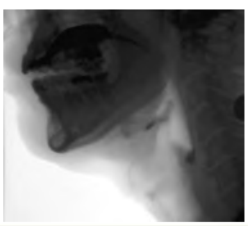
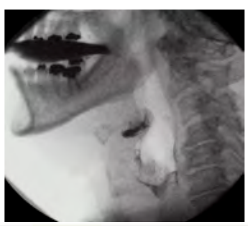
Consider Each Component in the Context of Swallowing as a Whole

Initiation Pharyngeal Swallow score of (3), bolus head in pyriforms

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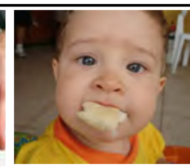
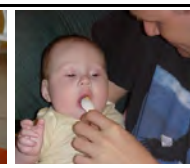


Impacts the Entire Age Spectrum

Fragile Young

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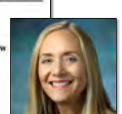

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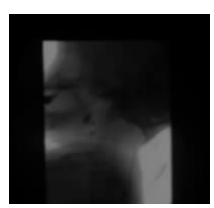
Lingual Motion/Pharyngeal Swallow Initiation:
Number of Sucks to Form Bolus for Swallowing



1 = Sucking 1x
2 = Sucking 2x
3 = Sucking 3x
4 = Sucking 4x
5 = Sucking 5x
6 = Sucking ≥ 6x
7 = Sucking without liquid flow from nipple

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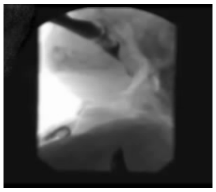
Lingual Motion/Pharyngeal Swallow Initiation: Initiation of Pharyngeal Swallow



0 = Above or at valleculae
1 = Between valleculae and pyriform sinuses
2 = In pyriform sinuses
3 = No initiation

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Results

Confirmatory Factor Analyses for 23 Swallowing Components

eigenvalues ≥ 0.5
eigenvalues ≤ 0.5

Components	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
19. Amount of Penetration	0.991	0.098	0.071	0.093	0.092
20. Frequency of Penetration	0.890	0.153	-0.006	0.018	-0.005
11. Early Laryngeal Vestibular Closure	0.846	0.069	-0.020	0.340	0.054
18. Timing of Airway Entry	0.748	0.268	-0.013	0.407	0.027
12. Late Laryngeal Vestibular Closure[a]	0.635	0.084	0.012	0.570	0.105
17. Pyriform Residue	0.018	0.814	0.135	0.141	0.086
13. Epiglottic Movement	0.039	0.752	0.089	-0.073	0.160
16. Valleculae Residue	0.062	0.715	-0.027	0.165	0.160
14. Tongue Base Retraction	0.168	0.689	0.078	0.079	0.204
23. Pharyngoesophageal Segment (UES)	0.109	0.675	0.054	0.090	0.017
15. Pharyngeal Stripping Wave	0.223	0.579	0.142	0.028	0.155
5. Oral Residue at end of Suck/Swallow Sequence	0.014	0.410	0.224	0.169	0.035
6. Suck/Swallow Bolus Control	0.105	-0.200	0.931	-0.115	0.020
7. Bolus Location at Initiation of Pharyngeal Swallow	0.333	0.028	0.718	-0.101	0.029
2. Initiation of Nutritive Sucks	-0.045	0.180	0.712	0.088	0.124
8. Timing of Initiation of Pharyngeal Swallow	-0.051	0.203	0.687	-0.176	-0.066
4. Nutritive Suck Rhythmicity/Organization	-0.125	0.169	0.649	0.0620	0.023
3. Number of Sucks to Form Bolus	0.027	0.131	0.550	-0.037	0.021
1. Lip Closure	-0.044	0.017	0.356	0.157	0.146
21. Amount of Aspiration	0.319	0.201	-0.035	0.913	0.056
22. Frequency of Aspiration	0.342	0.248	-0.063	0.820	0.038
9. Palatal-Pharyngeal (P-P) Approximation/Palatal Integrity	0.103	0.392	0.122	0.044	0.896
10. Location of Bolus at Time of P-P Approximation	0.076	0.351	0.132	0.080	0.884

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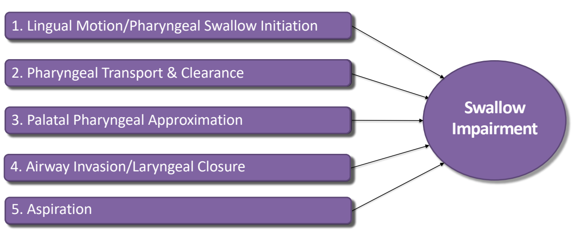
CFA Results

FIVE FACTOR SOLUTION



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Results

EXTERNAL INDICATORS

Spearman correlation of VFSS domain scores with feeding and quality of life measures

Measure	Airway Invasion/ Laryngeal Closure		Pharyngeal Transport and Clearance		Lingual Motion/ Pharyngeal Swallow Initiation		Aspiration		Palatal Pharyngeal Approximation	
	rs	P value	rs	P value	rs	P value	rs	P value	rs	P value
FS-IS:										
Limits subscale	-0.04	0.47	-0.08	0.15	0.13	0.04	-0.04	0.47	-0.06	0.29
Prevents subscale	-0.08	0.15	-0.05	0.43	0.12	0.06	-0.12	0.04	-0.08	0.15
Worry subscale	-0.01	0.92	0.10	0.10	0.09	0.15	-0.05	0.36	0.01	0.85
Feeding subscale	0.03	0.61	0.02	0.71	0.10	0.14	-0.04	0.50	-0.01	0.90
Worry breathing item	0.04	0.49	0.12	0.04	0.08	0.23	0.02	0.68	0.09	0.14
Feeding recs:										
Post VFSS	0.14	0.02	0.22	<0.001	-0.13	0.046	0.34	<0.001	0.19	0.001
Pre VFSS	-0.02	0.76	0.13	0.02	-0.04	0.56	0.18	0.002	0.11	0.05
Change (Post – Pre)	-0.11	0.06	-0.01	0.80	0.06	0.33	-0.05	0.42	-0.02	0.69
PAS(max)	0.66	<0.001	0.21	<0.001	-0.10	0.14	0.88	<0.001	0.11	0.06

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Dysphagia
https://doi.org/10.1007/s00455-019-10008-x

ORIGINAL ARTICLE

BaByVFSSImP© A Novel Measurement Tool for Videofluoroscopic Assessment of Swallowing Impairment in Bottle-Fed Babies: Establishing a Standard

Bonnie Martin-Harris · Kathryn A. Carson · Jeanne M. Pinto · Maureen A. Lefton-Greif

Received: 4 February 2019 / Accepted: 28 March 2019
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Abstract
Aim This investigation tested the construct validity of the first standardized assessment tool, the BaByVFSS Impairment Profile, (BaByVFSSImP©), developed for the quantification of swallowing observations made from videofluoroscopic swallow studies (VFSS) in bottle-fed babies.
Method Construct validity of the measures was tested using descriptive methods and confirmatory factor analysis (CFA) of swallowing scores obtained from a cohort of bottle-fed babies (median age 3 months 1 day, interquartile range 1 month 4 days–7 months 4 days) sequentially referred for VFSS based on clinical signs, symptoms, or risk factors associated with dysphagia and/or aspiration. Main outcome measures were emergence of functional domains derived from swallowing component impairment scores.
Results Confirmatory factor analysis resulted in 21 significant components (factor loadings ≥ 0.5) grouping into five functional domains labeled for common contribution to overall swallowing function. The tool was organized into the BaByVFSSImP. Clinical relevance was explored using correlational analyses between domain scores, maximum penetration/aspiration scores, feeding status, and caregiver burden.
Interpretation Quantification of physiologic swallowing impairment captured by BaByVFSSImP holds promise for identification of physiologically based targets for intervention, clinical decisions regarding enteral feeding, and tracking the trajectory of swallowing impairment throughout development in young children.

Keywords Infant · VFSS · MBS · Reliability · Dysphagia · Deglutition · Deglutition disorders

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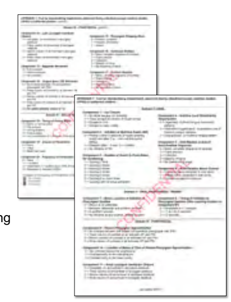
Impact

- Tool developed toward standardization of physiologic swallowing impairment in bottle-fed babies: BaByVFSS Impairment Profile (BaByVFSSImP)
- Factor structure supports content validity
- Identification of physiological targets
- Potential biomarkers that predict future feeding, swallowing and communication-cognitive development



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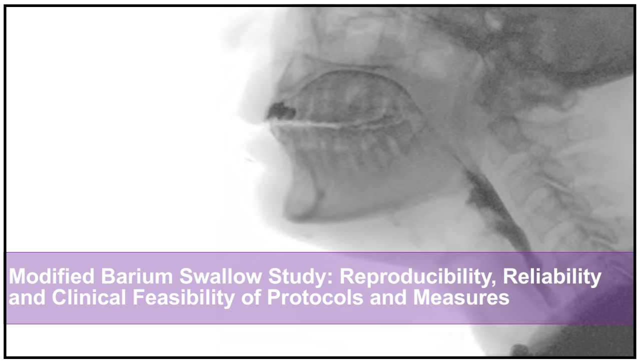

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Standardization

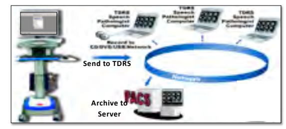
MBSS Recording is a Medical Record!

The goal is to retain DIAGNOSTIC image quality:

*The level of image quality that is deemed appropriate for answering a particular clinical question with **high diagnostic accuracy** and confidence.* (Stiller, 2017)

Factors that can influence image quality:

- Fluoroscopy **pulse rate**
- Recording **frame rate** and **resolution**
- **Compression** of native file format



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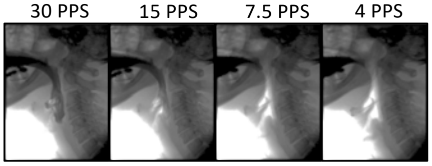
Standardization

MBSS Recording is a Medical Record!

Fluoroscopy Rate

30 PPS 15 PPS 7.5 PPS 4 PPS



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Dysphagia (2013) 28:77–85

ORIGINAL ARTICLE

Radiation Exposure Time during MBSS: Influence of Swallowing Impairment Severity, Medical Diagnosis, Clinician Experience, and Standardized Protocol Use

Heather Shaw Bonilha · Kate Humphries · Julie Blair · Elizabeth G. Hill · Katlyn McGrattan · Brittni Carnes · Walter Huda · Bonnie Martin-Harris

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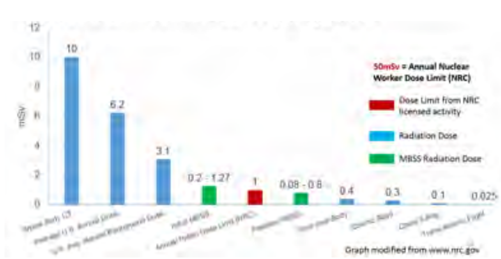
Effective Dose of an Adult MBSS



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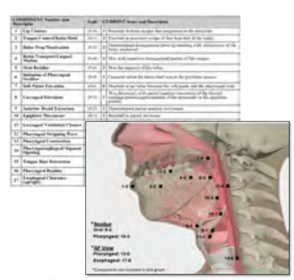
Standardized Reporting



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Standardization

- Acceptance of a standardization does not imply rigidity or lack of critical thinking
- Normal variation occurs in the physiological components of swallowing. More old news!
- A high score on one component of swallowing in a healthy, non-dysphagic person does not mean it should be eliminated from assessment in dysphagic patient.

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Standardization

- No scale is perfect
- Any measure with human interface is perceptual
- Clinical validation is critical
- Necessity of precision dependent on the nature of the question
- Sustained reliability requires team calibration

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Challenges of Dissemination and Implementation into Clinical Practice

- When effectively disseminated, why does evidence remain separate from and not integrated into clinical decisions and actions?
- Is it the *simple is better* mentality?
- Is it the *well-oiled machine* mentality?

If we want to MOVE FORWARD we can't keep going backward

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Clinical Translation

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Dissemination

27 Countries

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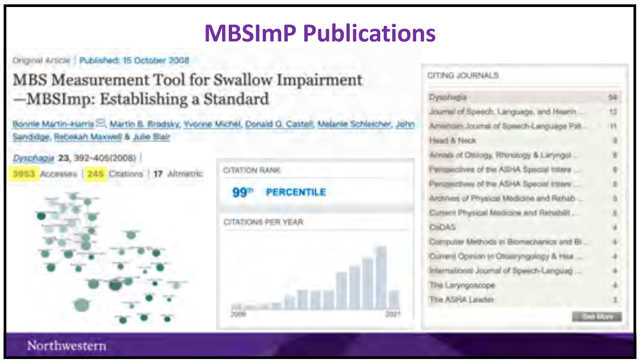

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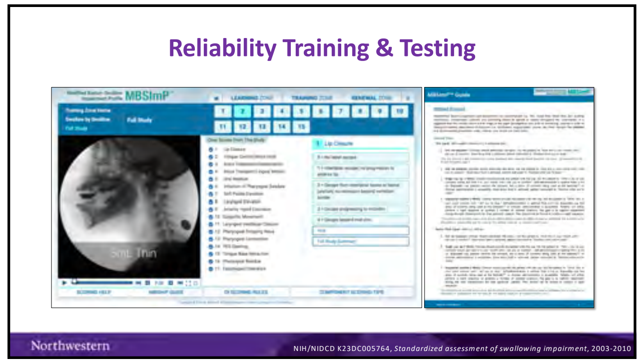

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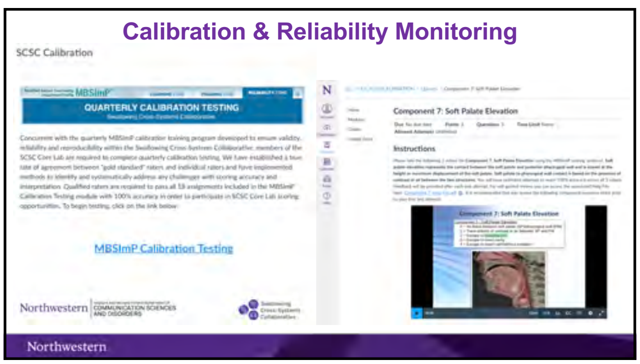

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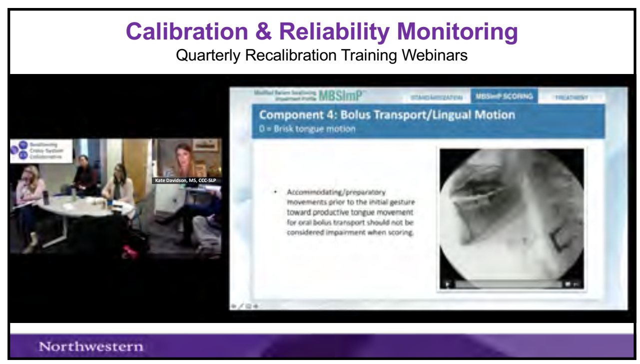

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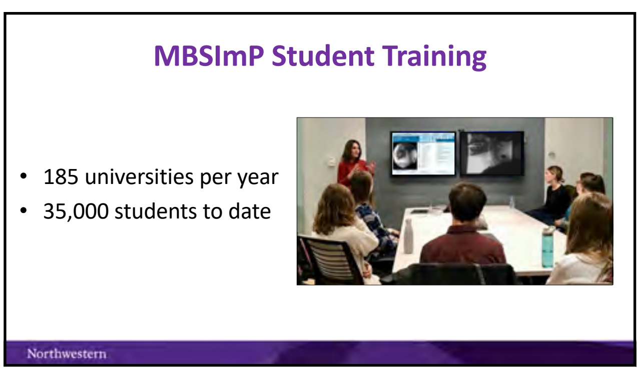

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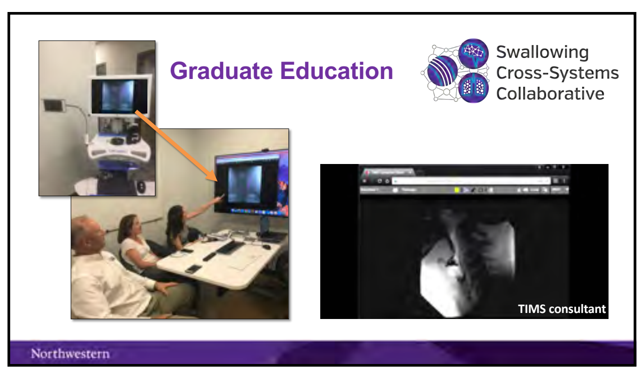

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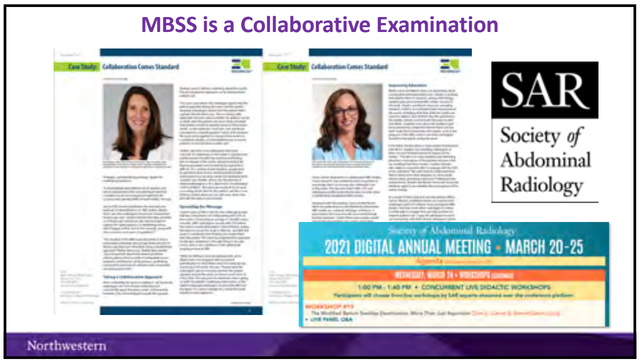

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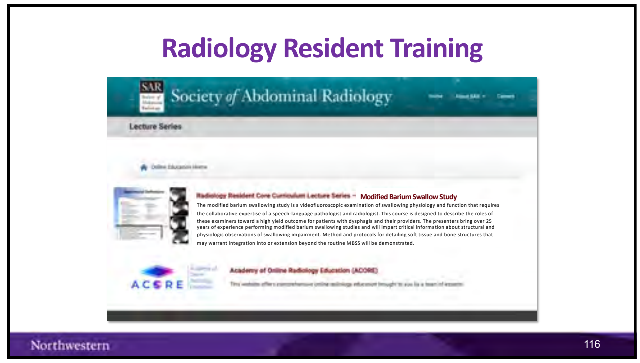

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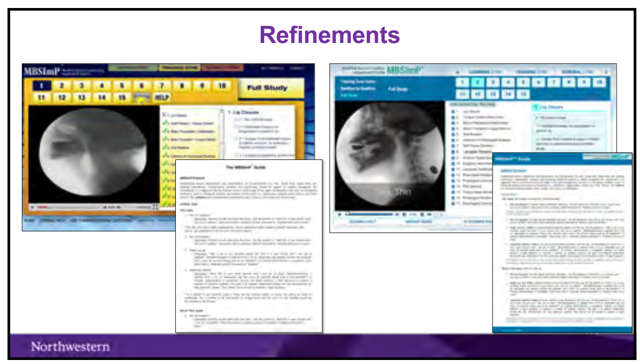

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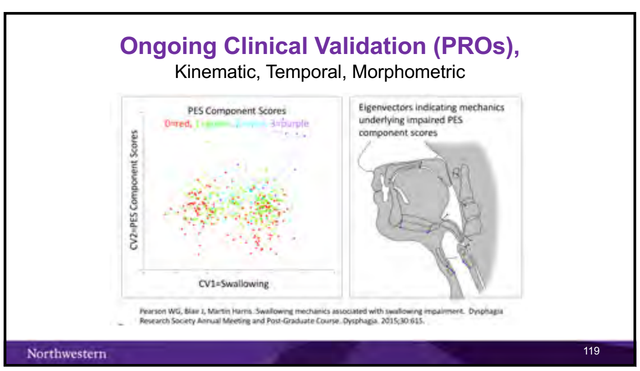

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MBSS Changes Lives

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Targeted Therapies Derived from Standardized Assessments: Frontline Tactics, Compensation, Adaptation

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Goals of Targeted Intervention

- Improve, maintain or prolong swallowing function
- Improve, maintain or prolong associated physiologic reserve (cross-system)
  - respiratory capacity, airway defense, physiologic capacity
- Maximize oral intake
- Facilitate least restrictive diet
- Maximize quality of life
- Actively engage patient in their rehabilitation or maintenance program

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Targeted Intervention

- Patient-specific:
  - ***underlying impairment,***
  - medical diagnosis,
  - cognitive status,
  - medical status,
  - patient/caregiver preferences
- Evidence-based (literature, expertise, preference)
- Based on observations of **pathophysiology** during instrumental assessment

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Multi-modality Dysphagia Intervention

- **Compensation:** improve safety and efficiency of swallowing ***without*** directly targeting swallowing physiology; "adapt" to impairment
- **Retraining:** improve safety and efficiency of swallowing by ***directly*** targeting swallowing physiology; "repair" impairment
- **Surgical\Medical Intervention:** most often used in conjunction with behavioral rehabilitation.

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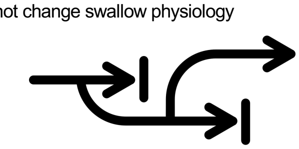
Compensatory Interventions

- Used as adaptation for structural and physiological deficits
- Should be evaluated during instrumental assessment to determine effectiveness
- Temporary effect only; does not change swallow physiology
- Not the same as "recovery"



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Indications and Contraindications

- Indications
  - Cognitive function adequate to follow instructions
  - Caregiver support for strategy implementation
- Contraindications
  - Poor cognitive function
  - Does not wish to use strategies

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Compensatory Interventions

1. Modify foods and liquids
2. Sensory stimulation
3. Utilize prosthesis
4. Alter posture
5. Employ maneuver

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Frontline Tactics – Fluids & Foods

Modify fluids and foods:

- Change viscosity/rheologic parameters
- Alter texture (e.g. cohesion)
- Enhance taste/temperature (sensory)

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Rheologic Parameters

- Diagnostic materials must have a standardized and meaningful relationship to our treatments (fluids & foods)
- Begin with viscosity (cps)

Product	Viscosity range*
VARIBAR® THIN LIQUID (barium sulfate) for oral suspension	[illegible]
VARIBAR® NECTAR (barium sulfate) oral suspension	150-450 cps
VARIBAR® THIN HONEY (barium sulfate) oral suspension	[illegible]
VARIBAR® HONEY (barium sulfate) oral suspension	[illegible]
VARIBAR® PUDDING (barium sulfate) oral paste	[illegible]

Varibar
(barium sulfate) 40% (w/v)

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Conversions

Varibar → International Dysphagia Diet Standardization Initiative (IDDSI)

Rheologic Properties

- Viscosity
- Flow
- Yield stress
- Shear rate

Varibar Product	IDDSI Syringe Flow Test Result (ml)		IDDSI Result (Level # and Name)
	Mean	Standard Deviation	
Thin 40%	0.0	0.0	Level 0 - Thin
Nectar 40%	4.9	0.4	Level 2 - Mildly-thick
Thin Honey 40%	9.8	0.0	Level 3 - Moderately-thick
Honey 40%	9.9	0.1	? Level 4 - Extremely thick

Table 2: IDDSI Syringe Flow Test results for Bracco Varibar® barium products.

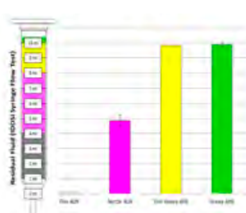

Figure 1: IDDSI Syringe Flow Test Results for Bracco Varibar® barium products.

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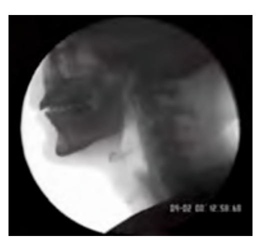
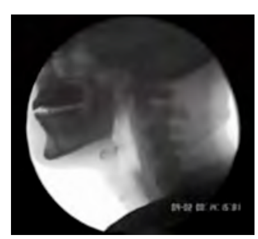
Response to Increased Bolus Viscosity

Component 12: Pharyngeal Stripping Wave



Thin Liquid



Pudding Consistency

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Sensory Awareness Techniques

- **Targets:**
  - Component 6: Initiation of the Pharyngeal Swallow
- **Sensory receptors include:**
  - Taste
  - Temperature
  - Tactile

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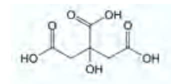
Taste – Sour Bolus



Indications for Use:
- Component 6: Delayed initiation of pharyngeal swallow
- Component 13: Pharyngeal Contraction

Impact:
- Increased stimulation of oropharyngeal receptors → activation of swallowing centers (nucleus tractus solitarius, nucleus ambiguus) (Ding et al., 2003; Logemann et al., 1995; Palmer et al., 2005)
- Shortens swallow duration (Ding et al., 2003; Logemann et al., 1995; Palmer et al., 2005)
- Increases amplitude of muscle contraction (Ding et al., 2003; Palmer et al., 2005)
- Reduces incidence of penetration/aspiration (Pelletier & Lawless, 2003)
- Increases number of spontaneous swallows (Pelletier & Lawless, 2003)

Evidence:
- Swallow function improved with an unpalatable 2.7% w/v citric acid-deionized bolus in neurogenic dyspahgia, but not with a more palatable 1.1% w/v citric acid-8% w/v sucrose mixture. (Pelletier & Lawless, 2003)

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Thermal Tactile Stimulation (TTS)

Targets:
- Component 6: Initiation of the Pharyngeal Swallow

Impact:
- Temporarily stimulate afferent receptors to trigger swallow reflex (Lazarra, Lazarus & Logemann, 1986; Rosenbeck et al., 1991, 1996; Byeon & Koh, 2016)

Evidence:
- Significant amplitude changes in pharyngeal motor evoked potential (MEPS) when using TTS on healthy participants (n=18). (Magara et al. 2018)
- No current evidence supporting long-term carryover to non-TTS facilitated swallowing.

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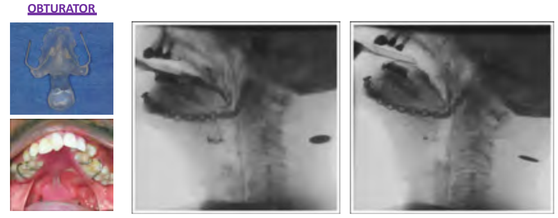
Appliances & Prostheses

Soft Palate Elevation Response to Obturator

OBTURATOR



* Clinical validation of interventions

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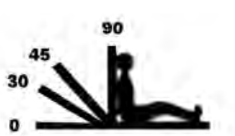
Optimal Positioning

- Upright between 70 – 90 degrees
- Head neutral position



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Postural Techniques

- Reclined (semi-supine)
- Head Extension (head back)
- Recumbent (side-lying)
- Head Lateral Flexion (head tilt)
- Head Flexion (chin tuck)
- Head Rotation (head turn)
- Postural Combinations (head flexion + rotation)

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Bolus Transport and Airway Protection

Response to Reclined Position

Syringe Nectar

Syringe Nectar, Reclined

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Swallow Maneuvers

- Immediately alter pharyngeal swallow to improve safety and efficiency of the swallow
- Alter timing, bolus flow or duration of swallow-related events
- Use temporarily during retraining to improve swallow function
- Maneuvers
  - Supraglottic
  - Super-supraglottic
  - Effortful
  - Mendelsohn

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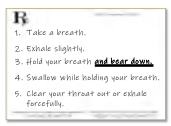
Super-supraglottic Swallow



Targets:

- Component 6: Initiation of the Pharyngeal Swallow
- Component 8: Laryngeal Elevation
- Component 11: Laryngeal Vestibular Closure

Impact:

- Similar effects to swallowing physiology as supraglottic swallow.
- **Effortful** breath hold brings arytenoids forward to close vestibular entrance *before and during* the swallow. (Martin et al., 1993; Logemann, 1983, 1998)
- Provides increased laryngeal vestibule protection and maintain airway protection longer than the supraglottic swallow. (Ohmae et al., 1996; Donzelli & Brady, 2004)

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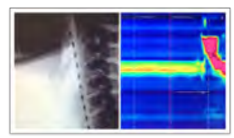
Effortful Swallow

Targets:

- Component 10: Epiglottic Movement
- Component 12: Pharyngeal Stripping Wave
- Component 13: Pharyngeal Contraction
- Component 15: Tongue Base Retraction
- Component 16: Pharyngeal Residue



Impact:

- Increases extent and duration of oral and pharyngeal pressures (Hind et al., 1991; Hiss & Huckabee, 2005; Huckabee et al., 2005; Huckabee & Steele, 2006; Pouderoux & Kahrilas, 1995; Kahrilas et al., 1992, 1993; Clark & Shelton, 2014; Molfenter et al., 2018)
- Increases tongue base retraction and posterior pharyngeal wall movement and pressures (Pouderoux & Kahrilas, 1995 Kahrilas et al., 1992, 1993; Clark & Shelton 2014; Huckabee & Cannito 1999; Lazarus et al., 2002)
- Reduces depth of laryngeal penetration (Bulow, Olsson, & Ekberg, 2001)
- Increases duration of anterior hyoid excursion and laryngeal vestibular closure (Hind et al., 2001, Jang et al., 2015)
- Increases linguapalatal pressures (Clark & Shelton, 2014, Fukuoka et al., 2013)
- Increases velocity, amplitude and duration of epiglottic inversion (Jang et al., 2015)

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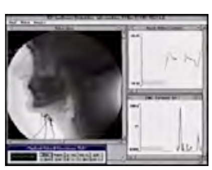
Mendelsohn Maneuver

Targets:

- Component 9: Anterior Hyoid Excursion
- Component 11: Laryngeal Vestibular Closure
- Component 14: Pharyngoesophageal Segment Opening



Impact:

- Increases the extent and duration of laryngeal excursion (Kahrilas et al., 1991, Lazarus et al., 2002; Inamoto et al., 2018)
- Increases the extent and duration of PES opening (Kahrilas et al., 1991; Lazarus et al., 1993; Inamoto et al., 2018)
- Prolonged duration of tongue base to posterior pharyngeal wall contact (Lazarus, Logemann, & Gibbons, 1993; Hoffman et al., 2012)
- Improved bolus clearance and airway protection (Lazarus, Logemann, & Gibbons, 1993; Lazarus et al., 2002)
- Facilitates and sustains laryngeal closure (Cook et al., 1989; Jacob et al., 1989)
- Facilitates and sustains contraction of oropharyngeal muscles (Boden et al., 2006)
- Increased velopharyngeal pressure duration (Hoffman, et al., 2012)

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Targeted Therapies Derived from Standardized Assessments: Strengthening, Skill, Assistive Technology

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Retraining (Rehabilitation)

- Retraining can lead to recovery/reacquisition of skills
- Behavioral rehabilitative swallowing interventions
  - Change swallowing physiology (improve swallowing (functional) outcomes)
  - Facilitated by motor skill acquisition
  - Potentially lead to neuroplastic changes (adaptive or maladaptive)

Northwestern   Cohen et al., 1997; Clark, 2003; Robbins et al., 2008; Levin et al., 2009; Langmore & Pisegna, 2015

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Principles of Exercise Rehabilitation

Table 1. Principles of experience-dependent plasticity.

Principle	Description
1. Use It or Lose It	Failure to drive specific brain functions can lead to functional degradation.
2. Use It and Improve It	Training that drives a specific brain function can lead to an enhancement of that function.
3. Specificity	The nature of the training experience dictates the nature of the plasticity.
4. Repetition Matters	Induction of plasticity requires sufficient repetition.
5. Intensity Matters	Induction of plasticity requires sufficient training intensity.
6. Time Matters	Different forms of plasticity occur at different times during training.
7. Salience Matters	The training experience must be sufficiently salient to induce plasticity.
8. Age Matters	Training-induced plasticity occurs more readily in younger brains.
9. Transference	Plasticity in response to one training experience can enhance the acquisition of similar behaviors.
10. Interference	Plasticity in response to one experience can interfere with the acquisition of other behaviors.

Northwestern   Kleim & Jones, 2008

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Behavioral Retraining Approaches

"When behavioral re-training approaches ***are appropriate for a specific patient*** *(and* ***his/her pathophysiology****)* ***AND they are implemented using principles of exercise physiology, motor learning, and neuroplasticity****, patient outcomes will very likely be positive"*

"Not only the specific exercises, but more importantly the way these exercises and programs are implemented is key to the success of the patients."

~Georgia Malandraki, SIG 13 List Serve

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Behavioral Retraining Approaches

Strength Training

- Lingual *(e.g., Robbins et al., 2007; Lazarus, 2006; review by: McKenna et al., 2017)*
- Hyolaryngeal *(e.g., Shaker, Mendelsohn)* *(Shaker et al., 1997; Mishra et al., 2015; McCullough et al., 2012)*

Skill Training

- Device facilitated biofeedback (e.g. Athukorala et al., 2014, Davidson & O'Rourke, 2019)

Programmatic Interventions

- Respiratory-swallowing Coordination Training (RST) (Martin-Harris et al., 2015)
- McNeil Dyspahgia Therapy Program (MDTP) (e.g., Crary et al., 2012)
- Boot Camp and Intensive Dysphagia Rehabilitation (IDR) approaches (Hutcheson et al., 2013; Malandraki et al., 2016)

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Strength Training and Skill Training

Impairment may be present in both, but not equally distributed…

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Strength Training

- Not all swallowing impairment has a neurologic basis.
- Strength changes with:
  - Aging
  - Head and neck cancer
  - Disuse
- Muscle atrophy occurs within the first 72 hours of:
  - Change in muscle workload
  - Disuse
  - Ischemia
  - Change in stimulation

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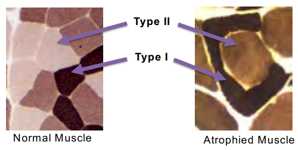
Disuse Atrophy

- Impact on swallowing muscles is great because of the high percentage of fast twitch (Type II) fibers
- Training preferentially targets those fibers which are critical for a safe and efficient swallow.



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Strength Training

- Muscles are highly responsive to exercise
- To increase strength, the muscle must be exercised at a level above its usual "load"
- Load increases gradually and systematically over time
- Through continued practice, muscles develop efficiency and stabilize motor plans – improved performance!
- Rest facilitates muscle benefits from exercise

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Strength Training Interventions

- Lingual Strengthening and Range of Motion (ROM)
- Mendelsohn Maneuver
- Effortful Swallow
- Masako Maneuver
- Shaker Exercise
- Chin Tuck Against Resistance (CTAR) Exercise
- Effortful Pitch Glide

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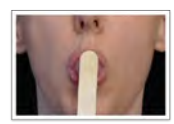
Lingual Strengthening & ROM

- Correlation between tongue strength and oral transit time and efficient bolus clearance (Robins et al., 2005)
- Improved tongue strength in healthy young and old (isometric tongue strengthening and resistance exercises) (Lazarus et al., 2003; Hind & Robbins, 2004; Robbins et al., 2005 & 2008)
- Improved maximum isometric tongue pressures, maximum swallow pressures, and PAS scores in patients with CVA (Kays et al., 2004)
- Increased ROM of the tongue and posterior pharyngeal wall (Fuji, Logemann, & Pauloski, 1995; Fuji & Logemann, 1996; Lazarus et al., 2003; Veis, Logemann, & Colangelo, 2000; Lazarus, Logemann, Pauloski, 2000)



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Iowa Oral Performance Instrument (IOPI)

- Isometric exercise (lip, tongue, cheek)
- Air-filled tongue bulb
- Biofeedback for strength training or endurance exercises
- Measurement of pressure (kPa)
- Target value = Max pressure x (Effort/100)
- Endurance: time to maintain 50% of max

IOPI Medical, LLC

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Tongueometer™

- Isometric exercise (tongue)
- Air-filled tongue bulb
- Biofeedback for strength training or endurance exercises
- Measurement of pressure (kPa)
- Assesses the length of time that a user can maintain a tongue pressure within a set pressure range of his or her maximum pressure
- Target = 60-80% of maximum strength

E2 Scientific Corp

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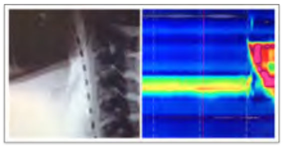
Mendelsohn Maneuver

Targets:
- Component 7: Soft Palate Elevation
- Component 8: Laryngeal Elevation
- Component 11: Laryngeal Vestibular Closure
- Component 14: PES Opening
- Component 15: Tongue Base Retraction



Evidence:
- Significant changes in duration of superior hyoid movement, swallow efficiency, and safety after 2 weeks of treatment (n=18, post stroke) (McCullough et al., 2012)

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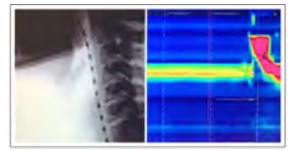
Effortful Swallow

Targets:
- Component 12: Pharyngeal Stripping Wave
- Component 13: Pharyngeal Contraction
- Component 15: Tongue Base Retraction



Evidence:
- Decreased aspiration of thins and semisolids following 20 session of Effortful + Mendelsohn (n=4). (Kim et al., 2017)
- Increased linguapalatal pressures after 4 weeks of training in 40 healthy adults. (Clark & Shelton, 2014)
- Improved manometric pharyngeal pressures following 2 weeks of training in 4 patients with Parkinson's Disease. (Felix, Correa & Soares, 2008)

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Masako Maneuver

Targets:
- Component 12: Pharyngeal Stripping Wave
- Component 15: Tongue Base Retraction

Impact:
- Increases contraction of superior pharyngeal constrictor (Fuji et al., 1996)
- Anterior tongue movement pulls pharyngeal wall forward (Saigusa et al., 2004)

Evidence:
- Limited, no controlled studies in *dysphagic individuals*
- Healthy subjects underwent 20 treatment sessions (performed Masako for 5 secs for 20 mins) over 4 weeks with no change. (Oh et al., 2012)

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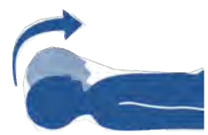
Shaker Exercise

Targets:
- Component 9: Anterior Hyoid Excursion
- Component 14: PES Opening



Intervention Approaches
1) Isometric: sustained head raising for one minute in supine position
2) Isotonic: 30 consecutive head lifts in supine position

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Shaker Exercise

Ohba, S., Yokoyama, J., Kojima, M., Fujimaki, M., et al. (2016). **Significant preservation of swallowing function in chemoradiotherapy for advanced head and neck cancer by prophylactic swallowing exercise.** Head & neck, 38(4), 517-521.	Logemann, J. A., Rademaker, A., Pauloski, B. R., et al. (2009). **A randomized study comparing the Shaker exercise with traditional therapy: a preliminary study.** Dysphagia, 24(4), 403.	Mepani, R., Antonik, S., Massey, B., Kern, M., Logemann, J., et al. (2009). **Augmentation of deglutitive thyrohyoid muscle shortening by the Shaker Exercise.** Dysphagia, 24(1), 26-31.
"Average movement of the hyoid bone, thyrohyoid shortening, and PES opening were significantly better maintained in the Shaker group. PAS for Shaker group was significantly lower than control group. Feeding tube rates for the Shaker and control groups were 14% and 40% (p < .05).	*"There was significantly less aspiration post-therapy in patients in the Shaker group... There was a significant increase in UES opening [post-tx] width on 3-ml paste swallows"*	*"After completion of therapy, the percent change in thyrohyoid distance in the Shaker Exercise group was significantly greater compared to the traditional therapy (p = 0.034)."*

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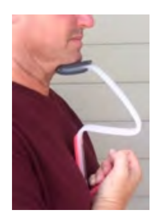
Chin Tuck Against Resistance (CTAR)

Targets:
- Component 3: Bolus Preparation/Mastication
- Component 9: Anterior Hyoid Excursion
- Component 14: PES Opening



Intervention Approaches:
- Chin tuck and hold position (isometric)
- Repetitive chin tucks (isotonic)
- Use ISO-CTAR device, CTAR ball, or towel
- Can combine with effortful swallow
- Jaw opening against resistance

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Chin Tuck Against Resistance (CTAR)

Sze, W., Yoon, W., Escoffier, N., & Liow, S. (2016). **Evaluating the training effects of two swallowing rehabilitation therapies using surface electromyography-CTAR exercise and the Shaker exercise.** Dysphagia, 31, 195-205.	Yoon, W., Khoo, J., & Liow, S. (2014). **Chin tuck against resistance (CTAR): New method for enhancing suprahyoid muscle activity using a shaker-type exercise.** Dysphagia, 29(2), 243-248.
"CTAR was more specific in targeting the suprahyoid muscles than the Shaker exercise… sEMG signals further indicated that the suprahyoid muscle group were equally or significantly fatigued (depending on metric), when participants carried out CTAR compared to the Shaker exercise. The sternocleidomastoid muscles were significantly less activated and fatigued during CTAR."	*"Significantly greater maximum sEMG values during the CTAR isokinetic and isometric exercises than during the equivalent Shaker exercises, and significantly greater mean sEMG values were observed for the CTAR isometric exercise than for the Shaker isometric exercise."*

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Effortful Pitch Glide

Falsetto + Pharyngeal Squeeze

Targets:
- Component 8: Laryngeal Elevation
- Component 12: Pharyngeal Stripping Wave
- Component 13: Pharyngeal Contraction

Impact:
- Elevation of the larynx is associated with production of high pitch in the modal register (Miloro et al., 2014; Echternach et al., 2011)
- Pharyngeal squeeze maneuver targets the long pharyngeal muscles that elevate the larynx and shorten the pharynx, improving pharyngeal strength (Miloro et al., 2014)

Instructions
1) Produce /i/ starting at the patient's comfortable pitch and glide up to their highest pitch
2) Once they reach their highest pitch, exert effort to produce a forceful /i/

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Outcomes: Effortful Pitch Glide


Pre-Tx


Post-Tx

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Neuromuscular Electrical Stimulation (NMES)

- Traditionally used in physical therapy
- Premise: voluntary contraction + electrical stimulation = increased movement
- In dysphagia, electrodes are placed on surface of head and neck
  - Low voltage electrical currents causing contraction of muscle fibers
- 2 electrodes types:
  - Anode and cathode (positive and negative charge)
  - Current arcs between electrodes
  - Tissues activated from superficial to deep

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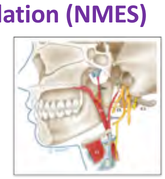
Neuromuscular Electrical Stimulation (NMES)



Targets:
- Component 8: Laryngeal Elevation
- Component 9: Anterior Hyoid Excursion
- Component 11: Laryngeal Vestibular Closure

Impact:
- Depresses hyoid (Ludlow et al., 2007)
- Reduces laryngeal and hyoid peak elevation (Humbert et al., 2007)
- Does NOT produce vocal fold adduction adequate for airway protection (Humbert et al., 2009)

Evidence:
- Effortful swallow + NMES:
  - Significant increased max vertical displacement of larynx compared to controls (n=20 stroke) (Park et al., 2012)
  - Significant increase in anterior-superior hyoid movement compared to controls (n=50 stroke) (Park et al., 2016)

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Skill Training

"Dysphagia is not always due to a deficit in muscle strength but can rather be attributed to limited precision and timing of muscular activation, thus, a limitation of swallowing skill, rather than strength".

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Sella, 2012

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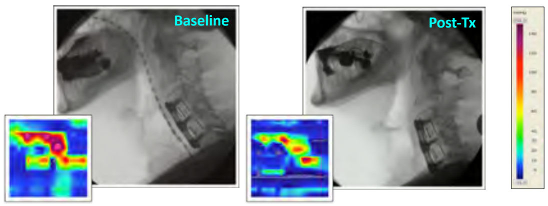
Skill Training

Swallowing depends on *precision* and *speed of movement* and does not always require *maximal* muscle contraction:



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Skill Training

- Skill based training must replicate the ***desired task → task specificity***
- Incorporate the exercise into the context of ***functional* swallowing**
- Utilize biofeedback to enhance awareness and precision of movements

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Biofeedback

Select Modalities

Fluoroscopy
Electromyography
Endoscopy
Manometry
Plethysmography

Paradigm shift to include skill training

Athukorala et al., 2014
Huckabee et al., 2013

Maximizes rehabilitation & improves outcomes

Azola et al., 2016
Martin-Harris et al., 2015
Macrae et al., 2014
Humbert & Joel, 2012
Crary et al. 2004
Kahrilas et al. 1993

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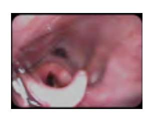
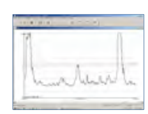
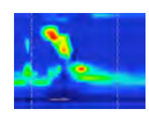
Biofeedback

- Swallowing produces limited external movement patterns and intrinsic feedback systems are likely impaired in the presence of dysphagia. (Huckabee & Macrae, 2014)
- Improved performance is heavily influenced by the presence of guidance and feedback. (Salomi, Schmidt, & Walter, 1984)


Endoscopy


Electromyography


Manometry

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Utility of Biofeedback

- Facilitates education and shaping of desired response
- Evaluates efficacy of interventions
- Monitors adherence and progress
- Provides quantitative, objective outcome data

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Candidacy for Biofeedback

- Observable phenomenon
  - Electromyography: Some degree of observable extrinsic muscle activity
  - Endoscopy: Impairment of components visible during endoscopy (delayed initiation pharyngeal swallow)
  - Manometry: Some degree of observable pharyngeal contractility
- Good visual acuity
- Intact cognition
- Ability to place/pass device:
  - Electromyography: radiation fibrosis, "woody neck" – poor candidate
  - Endoscopy: patent nasal passage for endoscope
  - Manometry: patent nasal passage and absence of stricture/severe kyphosis for catheter

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Surface Electromyography (sEMG)

- Uses surface electrodes to detect muscle activity
- Common placement sites
  - Orbicularis oris
  - Masseter
  - Submental group (suprahyoids)
  - Larynx (infrahyoids)

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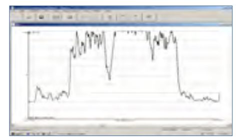
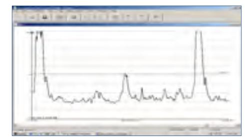
Surface Electromyography (sEMG)

- Duration of of laryngeal elevation (Mendelsohn Maneuver)
- Amount of electrical activity in submandibular muscles (Effortful Swallow)



Mendelsohn Maneuver



Effortful Swallow

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Steele et al., 2012

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Surface Electromyography (sEMG)


ACRM Archives of Physical Medicine and Rehabilitation

ORIGINAL ARTICLE

Skill Training for Swallowing Rehabilitation in Patients With Parkinson's Disease

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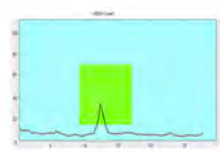
Skill Training for Swallowing Rehabilitation in Patients with PD

Athukorala et al., 2014

- Examined effect and retention of skill training on swallowing in individuals with PD
- n=10, 3 females, mean age 67.4y
- 10 daily sessions of skill training →
- Noted mprovements:
  - swallowing rate for liquids (p=.034),
  - sEMG durational parameters of premotor time (p=.003),
  - pre-swallow time (p<.001)
  - swallowing related quality of life (p=.018)
- Short-term retention at 2 weeks.



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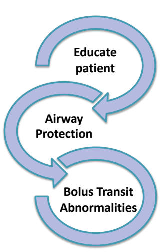
Applications of Endoscopic Biofeedback



- Swallowing deficits & consequences
- Show that techniques improve swallowing

- Glottic Closure
- Airway Protection

- Initiation Pharyngeal Swallow
- Pharyngeal Residue
- Show efficacy of strategies (e.g. liquid wash)

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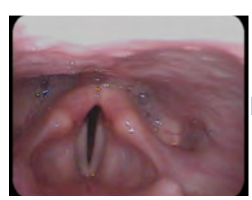
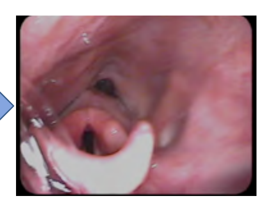
Endoscopic Biofeedback



Pt. with neurosarcoidosis, decreased PES opening



Head rotation facilitates PES opening

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Endoscopic Biofeedback

Denk DM, Kaider A. **Videoendoscopic biofeedback: a simple method to improve the efficacy of swallowing rehab of patients after head and neck surgery.** ORL J Otorhinolaryngol Relat Spec. 1997 Mar-Apr;59(2):100-5.	Leder SB, Novella S, Patwa H. **Use of fiberoptic endoscopic evaluation of swallowing (FEES) in patients with amyotrophic lateral sclerosis.** Dysphagia. 2004;19(3):177-81.	Imada M, Kagaya H, Ishiguro Y, et al. **Effect of visual biofeedback to acquire supraglottic swallow in healthy individuals: a randomized-controlled trial.** Int J Rehabil Res. 2016 Jun;39(2):181-4.
"Videoendoscopic biofeedbac k significantly increased the chance of therapeutic success, shortening the period of functional rehabilitation in comparison to conventional swallowing therapy."	*"Visual biofeedback provided by FEES was successful for both patient and family education and to investigate individualized therapeutic strategies that, if successful, can be implemented immediately."*	*"The median length of time to acquire SGS was 1.5 days in the biofeedback group and 3.5 days in the non-biofeedback group (P=0.04)."*

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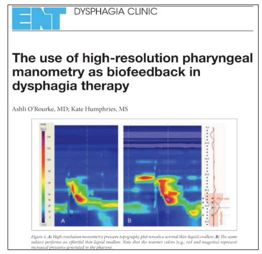
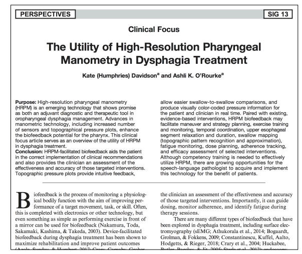
High-Resolution Pharyngeal Manometry (HRPM)


ENT DYSPHAGIA CLINIC

The use of high-resolution pharyngeal manometry as biofeedback in dysphagia therapy

Ashli O'Rourke, MD; Kate Humphries, MS

Figure 1. A: High-resolution manometry pressure topography plot reveals a normal thin-liquid swallow. B: The same subject performs an effortful thin-liquid swallow. Note that the warmer colors (e.g., red and magenta) represent increased pressures generated in the pharynx.


PERSPECTIVES | SIG 13

Clinical Focus

The Utility of High-Resolution Pharyngeal Manometry in Dysphagia Treatment

Kate (Humphries) Davidson[a] and Ashli K. O'Rourke[a]

Purpose: High-resolution pharyngeal manometry (HRPM) is an emerging technology that shows promise as both an adjuvant diagnostic and therapeutic tool in oropharyngeal dysphagia management. Advances in manometric technology, including increased number of sensors and topographical pressure plots, enhance the biofeedback potential for the pharynx. This clinical focus article serves as an overview of the utility of HRPM in dysphagia treatment.
Conclusion: HRPM-facilitated biofeedback aids the patient in the correct implementation of clinical recommendations and also provides the clinician an assessment of the effectiveness and accuracy of those targeted interventions. Topographic pressure plots provide intuitive feedback, allow easier swallow-to-swallow comparisons, and produce visually color-coded pressure information for the patient and clinician in real time. Paired with existing, evidence-based interventions, HRPM biofeedback may facilitate maneuver and strategy planning, exercise training and monitoring, temporal coordination, upper esophageal segment relaxation and duration, swallow mapping (topographic pattern recognition and approximation), fatigue monitoring, dose planning, adherence tracking, and efficacy assessment of selected interventions. Although competency training is needed to effectively utilize HRPM, there are growing opportunities for the speech-language pathologist to acquire and implement this technology for the benefit of patients.

Biofeedback is the process of monitoring a physiological bodily function with the aim of improving performance of a target movement, task, or skill. Often, this is completed with electronics or other technology, but even something as simple as performing exercise in front of a mirror can be used for biofeedback (Nakamura, Toda, Sakamaki, Kashima, & Takeda, 2003). Device-facilitated biofeedback during dysphagia treatment has been shown to maximize rehabilitation and improve patient outcomes ... the clinician an assessment of the effectiveness and accuracy of those targeted interventions. Importantly, it can guide dosing, monitor adherence, and identify fatigue during therapy sessions.

There are many different types of biofeedback that have been explored in dysphagia treatment, including surface electromyography (sEMG; Athukorala et al., 2014; Bogaardt, Grolman, & Fokkens, 2009; Constantinescu, Kuffel, Aalto, Hodgetts, & Rieger, 2018; Crary et al., 2004; Huckabee, ...

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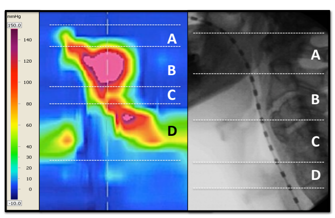
HRPM Landmarks

A) **Velopharyngeal Region**
- Soft palate
- Superior pharyngeal constrictors

B) **Mesopharyngeal Region**
- Tongue base
- Inferior pharyngeal constrictors
- Middle pharyngeal constrictors

C) **Hypopharynx Region**
- Inferior pharyngeal constrictors

D) **UES Region**
- Pharyngoesophageal segment



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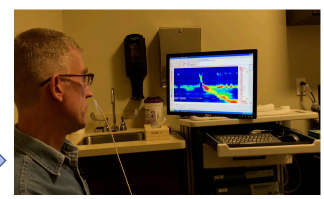
HRPM Intervention Applications

- Compensation/therapy planning
- Intervention training & monitoring
- Temporal coordination
- PES relaxation & duration
- Swallow mapping (pattern recognition and matching)



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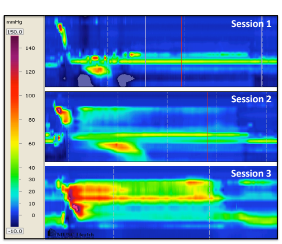
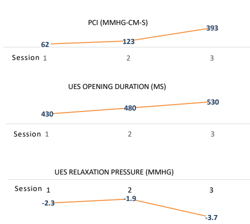
HRPM Training and Monitoring





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Evidence-Based Practice

"The conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients by integrating individual clinical expertise with the best available external clinical evidence from systematic research."

"Allows clinicians to be accountable, ethical, and responsible, not only to their clients, but to their profession and themselves and permits clinicians to account for their services when reporting to clients, their families, and third-party payers."

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Sacket et al., 1996; Apel & Self, 2003

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Treatment Efficacy

- Chose treatment protocols that have established efficacy or effectiveness.
- Not all published research is of equal rigor →
- Highest level of evidence:
  - meta-analysis of more than 1 randomized controlled trial (RCT)
  - single well-designed RCT
- There are few published research studies in dysphagia management in which RCTs have been conducted.
- Evaluate current evidence in context of what we know about swallowing physiology and recovery, and apply your interpretation of best practice.

Level	Description
I	Well-designed meta-analysis of more than 1 randomized controlled trial
II	Well-designed randomized controlled study
III	Well-designed controlled study without randomization
IV	Well-designed nonexperimental studies from more than 1 group
V	Expert committee report, consensus conference, clinical experience of respected authorities

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Sacket et al., 1996; Beasley & Snell, 2006; Suiter & Easterling 2007

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Best Practice

- Individualized variation → personalized approach
- Apply evidence-based approaches based on:
  - Patient factors (clinical, support, choice)
  - Cognitive factors
  - Environmental factors
  - Cultural factors
- Studies of normal do not necessarily translate to every disease or condition.
- Feasibility and push toward innovation – burden (time, access, cost)

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Thank you!

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