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Treating Oral Phase Dysphagia in Adults: Principles and Evidence

Nancy B. Swigert, MA, CCC-SLP, BCS-S

Moderated by:
Amy Natho, MS, CCC-SLP, CEU Administrator, SpeechPathology.com

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Treating Oral Phase Dysphagia in Adults: Principles and Evidence

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Disclosures

Financial

- Honorarium for this webinar
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Non-financial

- Serve on Medical Advisory Board for the Foundation on Swallowing Disorders
- Have written and presented on this topic previously

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Objectives

1. Describe the physiology of the oral phase of the swallow, and the relationship between oral and pharyngeal phases.
2. List principles of neuroplasticity and motor learning.
3. List examples of neuromuscular treatment for oral dysphagia and the nerves and muscles involved in each.
4. Identify the strengths and weaknesses of the evidence base for oral dysphagia treatment.
5. Describe the role of bolus modification/diet in managing oral dysphagia.

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Introduction

- To be a competent dysphagia clinician, the speech-language pathologist must have a solid knowledge of basic information:
  - Anatomy of oral, pharyngeal and esophageal structures
  - Physiology of the normal swallow
    - How nerves and muscles work together
    - Cortical and subcortical control of swallowing

In order to treat dysphagia in adults with rehabilitative/treatment techniques, the speech-language pathologist must understand:
- Principles of neuroplasticity
- Principles of motor learning
- How those principles help us apply neuromuscular treatments for oral and pharyngeal dysphagia
- Available evidence for exercises for dysphagia
- Rehabilitative and compensatory management strategies, including bolus modification
- Applying all this information to use a theory-driven approach to assessing exercise-based treatment
What is the oral phase?

**ORAL PREPARATORY**
- Bolus preparation
- Bolus maintenance
  - Anteriorly
  - Posteriorly

**ORAL (Oral Transit)**
- Bolus propulsion

- Any distinction between the oral and pharyngeal phase is a bit arbitrary
- The movement of the tongue starts the pharyngeal phase

Evidence-based practice

- What Is Evidence-Based Medicine?
  - Clinical Judgment
  - Relevant Scientific Evidence
  - Patients’ Values and Preferences

Limitations to evidence in swallowing

- Many studies done on normal individuals
- When done on patient population, can’t necessarily generalize it to another patient population
- Studies vary greatly in things like length of treatment
- Many studies claim short term effects only – don’t know about carryover
- In general, positive outcomes are reported

EBP takes so long… is there an alternative?

- Alternative is a theory-driven approach to care (Sidani and Braden, 1998)
  - Explicit identification of theory underlying the intervention
  - Should specify the nature of intervention, nature of expected effects, process mediating expected effects, and conditions under which the mediating processes occur
Theoretical soundness

- **Should** this treatment be beneficial vs.
- **Is** this treatment beneficial (Evidence-based)
- Judging theoretical soundness can work if the clinician understands the nature of the targeted impairment and the therapeutic mechanism of the selected technique
  - Clark 2003

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Oral phase treatment

<table>
<thead>
<tr>
<th>For More information about:</th>
<th>Refer to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural Plasticity</td>
<td>Kleim &amp; Jones 2008 “Principles of Experience-Dependent Neural Plasticity: Implications for Rehabilitation After Brain Damage”</td>
</tr>
<tr>
<td>Principles of neuroplasticity</td>
<td>Robbins et al 2008 “Swallowing and Dysphagia Rehabilitation: Translating Principles of Neural Plasticity into Clinically Oriented Evidence”</td>
</tr>
<tr>
<td>Neural control</td>
<td>Humbert &amp; German 2013 “New Directions for Understanding Neural Control in Swallowing” <em>Dysphagia</em> 28 (1) 1-10</td>
</tr>
</tbody>
</table>
Why understand related principles?

- Swallowing involves series of highly coordinated, volitional and reflexive sensorimotor movements in mouth, larynx, and pharynx
- To manage such a complex disorder, the SLP must understand underlying physiology and related principles

Without the understanding, how does the SLP answer:

- Can the impaired physiology actually be changed?
- Is it possible an exercise could cause more harm than good?
- How frequently should an exercise be practiced?
- How many repetitions of the exercise are needed to obtain a benefit?
- Should the practice be spaced out or massed together?
- At what point in recovery will dysphagia intervention be most beneficial?
Neural plasticity

- Brain’s ability to change, to alter neuronal systems in response to changes in input
- Swallowing therapy intends to achieve a behavioral change (e.g. more efficient movement of the bolus), but also a change in underlying neural pathways

Do changes in pathways happen?

- “Swallow neural substrates can undergo plastic changes as a function of experience, and…
- These swallowing neuroplastic changes may be associated with modulated swallowing behavior”
  - Martin 2009 p. 219
Does it always happen?

- Changes in neural pathways may result in behavioral change
- Only sometimes does behavioral change indicate neural plasticity occur
  - (Robbins et al 2008)

Ten principles of neural plasticity
(1) Use it or lose it

- If certain function is not used, behavioral response may degrade
  - A sport played in high school?
  - Dancing lessons?
  - Foreign language?
- What does this imply for patients we make NPO?

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(2) Use it and improve it

- Function can be improved through use
  - Especially if the activity involves not just practicing, but practicing designed to improve performance of the activity
    - Use of a coach for sports?
    - Instructor for dance or language lessons?
- What is implication for swallowing?
  - Just repetitive swallowing?
  - Or swallowing with instruction for improved performance?
- Does strength training really change cortical or subcortical maps?
  - E.g. head lift, EMST, lingual strengthening
- Or is skill training needed?
  - E.g. Effortful swallow

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(3) Plasticity is related to specific skill being practiced

- Changes may occur only in neural substrates involved in the behavior being trained
- Practicing one skill will not necessarily result in change to a different area of the brain
  - Would practicing tap make a person a better ballet dancer?
  - Practicing a tennis forehand improve golf swing?
  - Would an exercise for voice improve swallowing?
- *Basketball player at the foul line...* what’s more important to practice....
  - Passing the ball to a teammate?
  - The movement of the shoulders and wrist during the shot?
- Simple repetitive movements or strength training may not improve skilled movement
- E.g. Training on isotonic endurance task did not increase endurance on an isometric endurance task (Clark 2012)
  - Isotonic
  - Isometric

(4) Repetition matters

- In order to change neural substrates, practice must be extensive and continue for a period of time
  - Anyone take piano lessons as a child?
- Behavioral change is noted before neural change
- How extensive does swallowing “exercise” need to be? Simple repetition may not be enough
- How many repetitions?
- Over what length of time?
- One of the criticisms of NMES... is it just the “repetition” that results in change?
(5) Intensity matters

- In order to achieve neural change, activity must force the body beyond the typical level of activity in order to achieve neuromuscular adaptation (Pollock et al 1998)
- No pain, no gain?
- Body building…. Light weights or heavy weights?
  - Training long is not the same as training hard – would doing bicep curls with a one pound weight for 20 minutes = doing bicep curls with 15 pound weights for 60 seconds?
- Swallowing:
  - Burkhead (2007) suggests we should have patient work to point of fatigue rather than specific # reps or sets
  - Are two OP sessions a week “training hard”?

(6) Time matters

- Long periods of training and continuous training (rather than intermittent) may result in maximal neural change (Fisher & Sullivan 2001)
- Going to the gym for ten minutes a day? An hour a day?
- Going for a few days and then skipping weeks?
- Swallowing – at what point in recovery can patient benefit from long periods of continuous training?
  - Until that point, pair compensatory strategies with rehabilitative techniques patient can tolerate
(7) Salience matters

- Movement being practiced has to be important to the person, functional and related to the behavior being trained
- Client should understand how the exercises relate to the goal of improved swallowing
  - A patient receiving PT for a knee injury may be more likely to practice quadriceps strengthening exercises if he understands it will help him climb stairs

(8) Age Matters

- Younger brain is more adaptive and plastic
  - Neural plasticity does occur across the lifespan, though response decreased with age (Kramer et al 2004; Sawaki et al 2003)
  - Whew!!
- Swallowing therapy – does this affect our prognosis?
(9) Transference

- Plasticity in response to training one behavior can enhance acquisition of similar behaviors
  - Roller skating and roller blading ... and ice skating?
- Would training tongue lateralization to clear the sulci result in a neural change that would enhance tongue lateralization to place food on chewing surface?
- Would practicing bringing spoon to lips result in improved cup to lips? (and a change in different areas of the brain)?
- Would stimulation to change a sensory pathway result in any functional change in motor response of swallowing?
  - Is combined stimulation and skill learning necessary?

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(10) Interference

- Plasticity within a given neural structure can impede that structure from other more beneficial plasticity
  - Skiing vs. snowboarding: facing straight ahead vs. sideways; moving legs vs. moving whole body
- Inappropriate use of electrical stimulation can interfere with safe swallowing (in normal) (Fraser et al 2002)

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Neuromuscular impairments: weakness

Reduced ability to produce force

- Fatigue: weakness that becomes evident during sustained force production or over repeated trials

- Causes of weakness:
  - LMN damage (flaccid)
  - UMN damage (spastic)
  - General depression of function

- Weakness can disrupt speed and ROM

Weakness assessed perceptually – asking client to move against resistance

- Easier to observe in oral musculature (than pharyngeal)

- Weakness often accompanies dysphagia

- Difficult to determine the impact

See Clark article

Neuromuscular impairments: Disrupted muscle tone

- Tone is tendency of muscle to resist passive stretch

- Muscle spindles respond to lengthening by eliciting a ‘stretch reflex’, which causes the muscle to contract
  - This is perceived as resistance

- Tone can be disrupted by:
  - LMN damage (hypotonia)
  - UMN damage interrupts inhibitory signals, resulting in hypertonia
    - Spasticity
    - Rigidity (e.g. hypokineti‌ c dysarthria)
    - Variable tone

- Very difficult to recognize in swallowing musculature

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Exercise principles

- Muscle weakness may be the reason for dysphagia due to many causes
- Neuromuscular activities form basis of many treatments

How does exercise affect muscle?

- Causes muscle hypertrophy
  - Increase in number of muscle fibers (Type II)
- Stretch also induces fiber growth
- Immobility causes fiber atrophy
- Longer the immobility, greater the issue of atrophy
Muscle retraining

- Reactivation of muscle results in muscle gain
  - Improvement in indices
- More pronounced in muscles not previously weakened
- Be sure patient has good nutrition, otherwise the body feeds off the muscle
- Exercising atrophic muscle can cause damage

Muscle retraining/recovery

- Pre immobilization condition may be achieved
- Time for recovery depends on
  - Duration of disuse
  - Age of person
  - Conditions of immobilization
  - Specificity of training type used
- Initial changes from training are in improved motor unit recruitment
Functional Reserve

- The proportion of potential of force-generating capacity in relation to the effort required to perform a certain task.
- The less functional reserve that exists in proportion to the force needed to perform an activity, the more quickly the muscle will fatigue and the greater the individual's perception of effort will be.

Increasing functional reserve

- Strength, in its simplest terms, can be defined as the ability to generate force.
- To increase the force-generating capacity and therefore functional reserve, the physiologic load must exceed the demand typically encountered. This concept, known as the overload principle.
Principles of strength training: Overload

- Increases in strength, endurance and power result from two physiologic changes:
  - Hypertrophy of muscle fibers
  - Recruitment of additional motor units
- These only occur in response to overload
  - Muscle worked beyond typical workload in terms of force or time requirements
  - Demand must also be continuously increased in order for strength to continue to improve.
  - To increase strength, load of at least 60% required, then increasing to 80% every two weeks
  - To avoid overuse (injury) increase by no more than 10% week

Principles of strength training: Dynamics

**ISOTONIC**

- Muscles change in length while maintaining approximately same tension
- E.g. bicep curl (muscle flexing the elbow)

**ISOMETRIC**

- Muscle stays the same length, but changes tension
- E.g. bicep curl (muscle in hand holding the weight)

Strength gained for isometric not necessarily observed in isotonic
Keep in mind these criticisms of oral motor exercise for swallowing

- What we know about exercise and muscles comes from research on skeletal muscles
  - The same may not hold true for muscles in oral mechanism
- Some of the oral motor exercises do not adhere to principles like specificity (i.e. the exercise trained should closely match the desired functional movement)
  - So would a non-swallowing task really help a swallowing task?
- Once an exercise is stopped, detraining occurs

Considerations in choosing exercises for swallowing

- Difficult to isolate a specific muscle group, because so many muscles overlap
  - May need to address functional muscle groups (e.g. muscles that retract the tongue)
- Difficult to identify which contraction dynamics to address (e.g. isotonic? Isometric?)
  - During cup drinking, tongue tip may be performing isotonic while some stabilizing muscle groups may be performing isometric
Considerations in choosing exercise

- Exercise frequency: adequate recovery time must be provided between sessions
  - We don’t know what adequate recovery time is
- Exercise progression in limb muscles has been studied
  - Increase percent of measured maximum
  - Increase number of repetitions per set or number sets per session
  - Increase repetition and intensity simultaneously

A few other concepts to keep in mind

- Sensory feedback is important for learning a motor movement, predicting the accuracy of the movement and making corrections to the movement
- Swallowing involves top down (cortical control) and bottom-up peripheral input) processing
  - Chewing and unexpectedly encounter something hard
  - Sip of coffee much hotter than expected
- Swallowing movements occur on a continuum of reflexive to volitional
- Motor learning involves feedback and feed-forward control loops as the individual adapts motor movements
So … what is the SLP to do?

- Keep in mind all of the principles discussed when selecting exercises and establishing the treatment program

Dysphagia in adults

- Many etiologies
- Different courses of disease and recovery
- Patients with similar etiologies and at a similar stage in disease progression or recovery may have:
  - Very different goals
  - Different prognoses
  - Differing abilities to participate in treatment
Considerations in treatment planning

- There are multiple factors that clinicians should consider when choosing an approach to intervention, including a patient's life circumstances, preferences, coping mechanisms, and co-occurring medical issues.
- Combining different types of treatment strategies at different stages of disease

Selecting treatment techniques

- Rehabilitative Techniques –
  - Selected to match impaired physiology
- Compensatory strategies –
  - Selected to address a sign/symptom
    - Functional deficit
  - And to compensate for impaired physiology
Compensatory

- Compensate for lost or impaired function
- Not intended to improve impaired anatomy or physiology
- Achieve a more functional, safe or efficient swallow
  - Used by the patient during meals or trial swallows
- Focus on the sign/symptom presented
- May not require as much cognition from patient
- Benefits (safe, more efficient swallow) are immediate, not permanent
- Examples: External pressure to the cheek or placing bolus on strong side
Postural

- Used to re-direct bolus flow in oral, but mostly pharyngeal phases
  - Change size, shape of pharynx
  - In oral phase, postures can keep the bolus on the stronger side
- In oral phase:
  - Head tilt to keep bolus on stronger side of oral cavity

Bolus modifications

- Texture changes
- Temperature changes
- Viscosity changes
- Sensory changes (e.g. sour, carbonation)
- Size of bolus
- How bolus is presented (e.g. small sips, place bolus on strong side)
IDDSI

- International Dysphagia Diet Standardisation Initiative
- Much of what we do for oral dysphagia is to manage the deficits by changing the diet
- The IDDSI is an important change in how we describe diet and liquid, how we prepare the materials and educate about bolus modifications

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IDDSI Framework

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Detailed Descriptors & Testing Methods (Drinks)

Flow Test
IDDSI level depends on liquid remaining after 10 seconds flow.

IDDSI Testing Methods

Example videos of the IDDSI Flow Test can be found on YouTube and accessed through the resources page on the IDDSI website:

www.iddsi.org
Mapping to IDDSI - Drinks

Current NDD Liquids

0 Thin
1 Slightly Thick
2 Mildly Thick
3 Moderately Thick
4 Extremely Thick

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Visit the website

www.IDDSI.org

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Compensations: Purposely increasing control of swallow

- Patient is asked to hold the bolus until instructed to swallow
- Patient is asked to “prep” for the swallow by counting silently to three before swallowing
Rehabilitative

- Designed to alter (and in some cases have been demonstrated to) the physiology of the swallow
  - i.e. result in long-lasting behavioral changes (and maybe changes in neural pathways)
- Should target the underlying impaired physiology identified during assessment
- Require individual to **actively** participate and in most cases to follow complex directions

Rehabilitative + Compensatory

- Some strategies thought to be rehabilitative (i.e. result in lasting change in physiology) can also be used in a compensatory way (e.g. used to improve safety or efficiency of each swallow during a meal)
  - Effortful swallow
Typical treatment

- Uses a combination of compensatory and rehabilitative techniques
- Avoid having the patient use multiple compensations

Combining type of strategies

- Which strategy at what point in continuum of care?
- How well will individual be able to utilize different types of strategies?
- Are certain types of strategies more effective in certain settings (e.g. available caregivers to implement?)
Treating oral dysphagia

- Structures
- Nerves and muscles
- Techniques

Why learn about the structures?

- The structures are the architecture on which breathing and swallowing are built
  - Bones
  - Cartilages
  - Muscles
  - Tissue
- Provide the framework for the highly coordinated movements of swallowing
Why learn about neurophysiology of swallowing?

- If we hope dysphagia exercises are going to result in lasting improvement in swallowing, we need to have a basic understanding of how the brain and the cranial nerves work together. Understanding the brain helps us understand neuroplasticity.
- The cranial nerves are responsible for the sensory input to the structures as well as controlling the movements of the muscles of the:
  - Oral cavity
  - Hypopharynx
  - Pharynx
  - Larynx
  - Esophagus
  - Respiratory System
- Understand the reason for the impaired swallow.

Why is understanding neurophysiology of swallowing important?

- You might select the wrong treatment techniques for the problem:
  - A sign/symptom may have more than one possible physiologic cause.
- You might select a treatment technique or method which doesn’t even make sense for the problem (e.g. treating weakness when reduced coordination is the problem).
- You might select a treatment technique that could do more harm than good.
So why understand how nerve and muscles function?

- May think you are working on one muscle when you are really working on another (that is perhaps on top of the one you are hoping to target)
- You might be providing a treatment that is not beneficial to the type of muscle you are targeting
  - E.g. strength training may not be indicated for a particular disease
- You might be providing a treatment intended to stimulate a nerve when the neuromuscular junction no longer works, or the nerve is DE-innervated

Let’s look at muscles and innervations for motor and sensory for:

- Lips
- Jaw
- Cheeks
- Tongue (oral)
- Soft palate
The Six Cranial Nerves Involved in Speech and Swallowing

- CN V - - Trigeminal nerve
- CN VII - - Facial nerve
- CN IX - - Glossopharyngeal nerve
- CN X - - Vagus nerve
- CN XI - - Spinal accessory nerve
- CN XII - - Hypoglossal nerve

Mnemonic for the Cranial Nerves

<table>
<thead>
<tr>
<th>On</th>
<th>(olfactory)</th>
<th>Some</th>
<th>(sensory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old</td>
<td>(optic)</td>
<td>Say</td>
<td>(sensory)</td>
</tr>
<tr>
<td>Olympus’</td>
<td>(oculomotor)</td>
<td>Marry</td>
<td>(motor)</td>
</tr>
<tr>
<td>Towering</td>
<td>(trochlear)</td>
<td>Money</td>
<td>(motor)</td>
</tr>
<tr>
<td>Top</td>
<td>(trigeminal)</td>
<td>But</td>
<td>(both)</td>
</tr>
<tr>
<td>A</td>
<td>(abducens)</td>
<td>My</td>
<td>(motor)</td>
</tr>
<tr>
<td>Finn</td>
<td>(facial)</td>
<td>Mother*</td>
<td>(motor)</td>
</tr>
<tr>
<td>And</td>
<td>(auditory)</td>
<td>Says</td>
<td>(sensory)</td>
</tr>
<tr>
<td>German</td>
<td>(glossopharyngeal)</td>
<td>Bad</td>
<td>(both)</td>
</tr>
<tr>
<td>Vended</td>
<td>(vagus)</td>
<td>Business</td>
<td>(both)</td>
</tr>
<tr>
<td>At</td>
<td>(accessory)</td>
<td>Marry</td>
<td>(motor)</td>
</tr>
<tr>
<td>Hopps</td>
<td>(hypoglossal)</td>
<td>Money</td>
<td>(motor)</td>
</tr>
</tbody>
</table>
Oral cavity

- First part of the digestive tract
- Initiates digestive process
  - Mixes saliva
  - Start propulsion of bolus
- A quick review of the structures because we sometimes ignore some of these

Lips, tongue, teeth, hard and soft palate

Hard and soft palates. A: transverse rugae of hard palate; B: median raphe of hard palate; C: median raphe of soft palate.

http://emedicine.medscape.com/article/1899122-overview#a2
Cheeks, gums, floor of mouth

Floor of mouth. A: lingual frenulum; B: sublingual papillae

Lips

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
<th>Innervation - Motor</th>
<th>Innervation – Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccinator</td>
<td>Compresses lips Pulls corners of lips tight</td>
<td>VII Facial</td>
<td>V Trigeminal Nerve: Maxillary branch to upper lip</td>
</tr>
<tr>
<td>Orbicularis oris</td>
<td>Closes, opens, protrudes, inverts and twists lips</td>
<td>VII Facial</td>
<td>Mandibular branch to lower lip</td>
</tr>
</tbody>
</table>

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Muscles of lips

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Innervation to lips: MOTOR

CN VII Facial

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Sensory innervation to lips: sensory Trigeminal

Maxillary branch: sensation upper lip

Mandibular branch: sensation lower lip

IMPAIRED PHYSIOLOGY OF LIPS: IMPACT ON SWALLOWING

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in lip muscles</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
</table>
| Inability to compress lips | Can’t close on spoon  
Can’t drink from straw  
Loses liquid anteriorly when drinking from cup  
Can’t keep bolus in mouth |
| Can’t invert lips | Can’t invert top or bottom lip to use teeth to clean lips |
Lips: Techniques

- Intended to be rehabilitative:
  - Lips around lifesaver *
  - Lip strength training using Oral Screen
  - Pucker and retract *
  - Puff cheeks *
  - Resistance straws
  - ROM – to counteract fibrosis with RAD

- Intended to be compensatory:
  - External support to lips

- Postural
  - Chin up

- Bolus modifications
  - Thicker materials if losing bolus anteriorly
  - Reduce size of sip
  - Straw on stronger side

To see movies of some oral exercises visit: Swallowingfoundationdisorder.org

Devices for lip strengthening

- Lip Screen: Improved lip strength and swallowing capacity in patients with stroke after training with device
  - Hagg and Anniko (2008)

- No change in lip or cheek strength following 4 weeks training with high resistance straws
  - Shelton 2011;
Objectively measuring change in lip strength

- Iowa Oral Performance Instrument IOPI

**Jaw**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
<th>Innervation: Motor</th>
<th>Innervation: Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masseter</td>
<td>Elevates and closes mandible (helps with chewing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mylohyoid</td>
<td>Depresses jaw when hyoid bone is in fixed position (for taking in food)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elevates and pulls hyoid forward when mandible is fixed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digastric (anterior belly)</td>
<td>Raises hyoid bone if jaw is in fixed position (helps to open cricopharyngeus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depresses jaw if hyoid is in fixed position (for taking in food)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acts with infrahyoid to stabilize hyoid bone so tongue can move</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporalis</td>
<td>Closes or elevates mandible, retracts mandible (helps with chewing; maintenance of bolus in the mouth)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pterygoid medial lateral</td>
<td>Medial and lateral work together to grind (chewing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medial - work bilaterally to close jaw and unilaterally to shift jaw to opposite site</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lateral - work bilaterally to open jaw or pull forward and unilaterally to move jaw or chin to opposite side (chewing)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chewing muscles: jaw

Chewing muscles (superficial)

Chewing muscles (deep)

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Innervation to jaw muscles: trigeminal

IMPAIRED PHYSIOLOGY OF JAW: IMPACT ON SWALLOWING

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in jaw?</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased ability to open jaw wide&lt;br&gt;Decreased ability to rotate jaw</td>
<td>Inability to bite things like apple, sandwich&lt;br&gt;Decreased ability to masticate food</td>
</tr>
</tbody>
</table>
Jaw: Techniques

- Intended to be rehabilitative:
  - Open and close against resistance
  - ROM indicated to counteract fibrosis in RAD
- Used as compensation:
  - Hand under jaw for support
- Postural:
  - External support to jaw

Bolus modifications:
- Use foods requiring less mastication

Chewing gum

- Healthy adults no benefit from high resistance chewing gum
  - Found immediate decrease in chewing efficiency (Tzikis et al 1989)
- Healthy adults had increase in functional capacity of masticatory muscles and strength after chewing extra hard gum (Kiliardis et al 1995)
Cheeks

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
<th>Innervation-Motor</th>
<th>Innervation-Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccinator</td>
<td>Flattens and tightens cheeks</td>
<td>CN VII Facial</td>
<td>CN V Trigeminal Maxillary branch</td>
</tr>
</tbody>
</table>

肌的面颊

额纹肌

肌的面颊

Epicranial aponeurosis

Occipitofrontalis (frontalis belly)

Corrugator supercilii

Orbicularis oculi

Occipitofrontalis (ocipital belly)

Obicularis oris

Buccinator

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Innervation to cheeks: Motor

Innervation to cheeks: sensory Trigeminal
**IMPAIRED PHYSIOLOGY OF CHEEKS: IMPACT ON SWALLOWING**

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in cheeks</th>
<th>What symptoms it might cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inability to tighten the cheeks</td>
<td>Reduced ability to suck from straw</td>
</tr>
<tr>
<td></td>
<td>Food and liquid pool in buccal cavities</td>
</tr>
</tbody>
</table>

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**Cheeks: Techniques**

- **Intended to be rehabilitative:**
  - Pucker/retract lips

- **Compensatory:**
  - External pressure to cheek on weaker side
  - Place bolus on stronger side
  - Clean buccal cavity with tongue or finger
  - Rinse and clear

- **Postural**
  - Head tilt

- **Bolus modifications**
  - Foods that maintain cohesive bolus

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Cheek strength with IOPI

- Healthy adults – no change in cheek strength after 9 weeks of training with IOPI
  - Clark et al 2009

Before we move to the tongue... animation of oral phase
### Tongue extrinsic muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Function for breathing</th>
<th>Innervations - Motor</th>
<th>Innervations - Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genioglossus</td>
<td>Protrusion; press tongue to teeth or alveolar ridge (posterior fibers)</td>
<td>Counterbalance airflow through upper respiratory tract by stiffening and enlarging upper airways</td>
<td>CN XII Hypoglossal</td>
<td>CN V Trigeminal-anterior 2/3 general, VII Facial-anterior 2/3 taste, IX Glossopharyngeal posterior 1/3 general and taste, X Vagus posterior general</td>
</tr>
<tr>
<td>Stylloglossus</td>
<td>Pulls tongue up and back</td>
<td></td>
<td>CN XII Hypoglossal</td>
<td></td>
</tr>
<tr>
<td>Palatoglossus</td>
<td>Pulls tongue back to make the groove</td>
<td></td>
<td>CN X Vagus (pharyngeal branch) CN XI Accessory</td>
<td></td>
</tr>
<tr>
<td>Hyoglossus</td>
<td>Retracts or depresses tongue; elevates hyoid</td>
<td></td>
<td>CN XII Hypoglossal</td>
<td></td>
</tr>
</tbody>
</table>

---

**Extrinsic muscles of tongue**

![Extrinsic muscles of tongue](https://via.placeholder.com/150)

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Sensory to the tongue

**Motor:** Hypoglossal (XII), except Palatoglossus: Pharyngeal branch of Vagus (X)

**Posterior 1/3**
- Sensory and Taste: Glossopharyngeal (IX)
- Sensory: Lingual branch of V3 from Trigeminal (V)
- Taste: Chorda tympani branch of Facial (VII), carried by lingual branch

**Anterior 2/3**

Tongue: **intrinsic** muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Innervations - Motor</th>
<th>Innervations – Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior longitudinal</td>
<td>shortens tongue or may turn tip and lateral margins upward to create concave appearance lateralizes tongue</td>
<td>XII Hypoglossal</td>
<td></td>
</tr>
<tr>
<td>Inferior longitudinal</td>
<td>shortens tongue or pulls tip downward lateralizes tongue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse</td>
<td>Narrows and elongates tongue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>flattens the tongue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Intrinsic muscles of tongue

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Innervation to tongue: Hypoglossal and Vagus

Hypoglossal = all motor

Vagus = motor and sensory

Sensory also from Trigeminal, Facial and Glossopharyngeal

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<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in tongue muscles</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back of tongue to soft palate does not seal to keep bolus in mouth</td>
<td>Premature loss of bolus over back of tongue. Can result in penetration or aspiration</td>
</tr>
<tr>
<td>Base of tongue fails to pull back towards pharyngeal wall adequately</td>
<td>Residue in valleculae</td>
</tr>
<tr>
<td>Increased stage transition duration (is this perhaps a sensory deficit in the back of the tongue? OR sensory deficit in the pharynx?)</td>
<td>Penetration Aspiration before the swallow</td>
</tr>
<tr>
<td>Inability to protrude and retract tongue</td>
<td>Can’t move bolus back in oral cavity</td>
</tr>
<tr>
<td>Inability to cup, flatten, lateralize the tongue</td>
<td>Reduced ability to form and manipulate bolus Can’t clear residue</td>
</tr>
</tbody>
</table>

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Animation of tongue lateral view

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The tongue

- More attention being given to the tongue
- Tongue movement is the initiator for pharyngeal phase
- Better understanding of the inter-connectedness of the oral and pharyngeal phases

Different functions of different parts of the tongue
The tongue: Rehabilitative(?) Techniques

- Intended to be rehabilitative
  - Press tongue (tip, blade, sides, back) against tongue depressor to increase strength
  - Sweep tongue tip from front to back along hard palate
  - Lateralize tongue tip
  - Use of implements placed in mouth to show patient where to put pressure and with which part of the tongue

- Range of Motion
  - Indicated in H&N (to counteract fibrotic effects of radiation)

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The tongue: rehabilitative tongue base? Is this oral or pharyngeal?

- Tongue pull back
  - Done with healthy
  - Unassisted TPB likely no more effective for tongue base than swallowing
  - Adding resistance may increase TB activity

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Fig. 1 The tongue-resisted tongue pull-back exercise

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A Pilot Study of the Tongue Pull-Back Exercise for Improving Tongue-Base Retraction and Two Novel Methods to Add Resistance to the Tongue Pull-Back

Lasse Mørland, Lasse Sting, Catherine OP, Julie Lise

Received 19 June 2011/accepted 30 January 2012/Published online 9 February 2012
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Strength and accuracy training for tongue

- When training tongue strength, train for accuracy as well as increased strength
- Studies show strength training works, but often the effects are lost in detraining period
- Some studies show that tongue strength training then results in improved functional swallowing

Examples of lingual strengthening research

- Investigations by Lazarus [2003] and Robbins [2005] revealed that healthy lingual muscle trained at loads at or above 60% of 1RM does respond to isometric strengthening to improve force-generating capacity.
- Robbins [32005, 2004] also reported that following an eight-week progressive resistance lingual exercise program using the Iowa Oral Performance Instrument (IOPI) in dysphagic stroke patients, not only did maximal isometric pressure generation increase, but oral pressures during swallowing also improved.
  - In addition, patients in Robbins study improved swallowing function and safety as measured by the Aspiration-Penetration Scale
  - Although the isometric lingual strengthening tasks do not directly incorporate swallowing as part of the training regimen, improving the force-generating capacity during tongue-to-palate contact appears to impact swallowing function.
  - The ability to manipulate progressive increases in the pressure-generating goal with isometric lingual strengthening regimens is likely one of the keys to eliciting measurable and functional gains.
Mention in general; then McNeil?

- Miller and Watkin [1996] found that duration and amplitude of lingual force production progressively increased when participants swallowed boluses of increasing viscosity.
  - This evidence suggests that altering bolus viscosity may offer a practical method of loading lingual muscle while swallowing.
  - A limitation of this approach would be the difficulty in quantifying and progressively manipulating load over time.

Need more than subjective measure of strength

- Inexperienced and experienced raters judge tongue strength differently
- Correlations to specific functional aspects of the oral swallow differed between the rater groups
  - Clark et al 2003
Devices to measure strength

- Iowa Oral Performance Instrument (IOPI) (iopimedical.com)
- SwallowSTRONG (www.swallowsolutions.com)
- Tongueometer (E2Scientific.com)

Using the devices
Example of visual biofeedback with IOPI and SwallowStrong

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Tongue strength: impact on pharyngeal swallow

- Patients after stroke
- Isometric exercise increased tongue pressures
- Airway invasion reduced for liquids
- Robbins et al 2007

- Tongue strength can be improved with resistance training in patients post stroke
- Reduced vallecular residue
- Did not change scores on pen-asp
- Steele et al 2016

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- Isometric progressive oropharyngeal (I-PRO) protocol
- Work at 60% maximum first week and 80% maximum remainder of time
  - Readjust 80% maximum every 2 weeks
- Regimen: 10 reps, 3-times per day, 3 days per week for 8-weeks, 3-5 second contraction
  - Anterior tongue
  - Posterior tongue

TPSAT  Steele et al 2013

- TONGUE PRESSURE STRENGTH AND ACCURACY TRAINING (TPSAT)
- Lingual resistance 2-3 times per week, 45 minute sessions, 60 swallows
  - Isometric strength
    - 6 repetitions-anterior, 6 repetitions posterior
  - Accuracy-targets randomly selected between 20%-90% MIP
    - 6 repetitions-anterior, 6 repetitions posterior
  - Swallowing saliva
    - 6 repetitions-anterior
    - Repeat the 3 sets again
The tongue (oral phase): Compensatory Techniques

- Compensatory:
  - Bolus placement
  - Multiple swallows
  - Sensory input to tongue
  - Liquid mix or wash

- Postural:
  - Chin down
  - Chin up

- Bolus modifications:
  - Cohesive bolus
  - Increased texture
  - Sensory changes

---

Soft Palate/Facial Arches

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Function for breathing</th>
<th>Innervation Motor</th>
<th>Innervation Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensor veli palatini</td>
<td>Tenses soft palate; may help close nasopharynx</td>
<td>Velopharyngeal port open for respiration</td>
<td>V Trigeminal</td>
<td>CN VII Facial</td>
</tr>
<tr>
<td>Palatoglossus</td>
<td>narrows the faucial opening (this muscle is in the anterior faucial arch); pulls soft palate down and forward</td>
<td>V Trigeminal</td>
<td>X Vagus</td>
<td>CN IX Glossop.</td>
</tr>
<tr>
<td>Levator veli palatine</td>
<td>Lifts soft palate</td>
<td></td>
<td>X Vagus</td>
<td>CN X Vagus</td>
</tr>
<tr>
<td>Salpingopharyngeus</td>
<td>Lifts soft palate</td>
<td></td>
<td>X Vagus</td>
<td></td>
</tr>
</tbody>
</table>

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Muscles of soft palate/ faucial arches

Another look at the muscles
Innervation to soft palate: motor

Innervation to soft palate: sensory

And also X

VII Facial

Glossopharyngeal IX
### IMPAIRED PHYSIOLOGY OF SOFT PALATE: IMPACT ON SWALLOW

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in muscles of soft palate</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can’t elevate soft palate</td>
<td>Backflow of bolus to nasal cavity</td>
</tr>
<tr>
<td>Asymmetrical elevation of soft palate</td>
<td>Partial backflow to nasopharynx</td>
</tr>
<tr>
<td>Can’t pull palate tight against back of tongue</td>
<td>Loses bolus prematurely over the back of the tongue</td>
</tr>
</tbody>
</table>

---

Animation soft palate
Soft palate: Techniques

A few examples of oral dysphagia in disease states

- Oral dysphagia in RAD
- Oral dysphagia after stroke
- Oral dysphagia in dementia
Radiation Associated Dysphagia RAD

- Chemoradiation is now the standard of care for organ preservation
- Preserving the organ does not mean preserving function
- Cancers of the oropharynx are on the rise
- The effects of radiation differ in the acute, chronic and late stages
- The effects are cumulative
  - Sometimes the dysphagia doesn’t appear until years after treatment was completed

How Radiotherapy Can Cause Dysphagia

- **Changes to the mucosa**
  - Mucositis
  - Candida
  - Erythema
  - Edema
  - Odynophagia
  - Dysgeusia (taste)
  - Altered smell
- **Changes to saliva**
  - Thick mucous
  - Xerostomia
- **Other symptoms**
  - Reduced appetite
  - Fatigue
  - Nausea
  - Pain
Oropharyngeal symptoms after radiation

- Reduced soft palate elevation
- Reduced swallow initiation
- Reduced Base of Tongue (BOT) retraction
  - Thickened immobile epiglottis
  - Reduced laryngeal elevation
  - Reduced airway protection
  - Reduced pharyngeal contraction
  - Reduced cricopharyngeal opening
  - Stricture(s)
  - Webs

- Residue is common with aspiration after from the residue
  - Impact on oral phase typically related to surgical removal of oral structures

Late and chronic effects

- Trismus – Fibrosis of muscles of mastication
  - Reduce ability to open the jaw
- Lymphedema – Swelling caused by blockage of lymphatic system
  - Seen most in the limbs, but can impact face and neck (and thus swallowing)
- Fibrosis – Thickening and scarring of connective tissue
- Cranial nerve palsies
So what do we know about treating RAD?

- Increasing evidence that proactive, prophylactic swallowing exercise is important
  - Start even before radiation therapy begins
- Patients have better outcomes if they continue to eat and exercise during the course of radiation therapy

Exercise during and after radiation

- Work on strength and range of motion
- Choose targets based on instrumental exam
- Follow principles:
  - Intensity
  - Frequency
  - Duration
- Incorporate structured approach to advancing swallowing
  Work on correct form of swallowing
  Use a food hierarchy (McNeill Dysphagia Therapy Program)
Deficits observed after STROKE

Videofluoroscopic findings in patients post-stroke include:

- increased oral and pharyngeal transit times,
- Poor tongue control
- longer stage transition durations
- delayed initiation of laryngeal closure
- reduced laryngeal closure duration
- reduced range of motion of the hyoid bone
- decreased laryngeal elevation
- worse penetration-aspiration scale scores as compared with normal controls

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Treating the dysphagia

- Treat early to avoid muscle weakness and atrophy that can occur with disuse
- Neural networks for swallowing are capable of experience-dependent neural plasticity
  - induce through non-behavioral and behavioral swallowing interventions.

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Dysphagia in Dementia

Late stages dysphagia in dementia

- Not recognizing sensation of hunger or thirst
- Oral phase problems:
  - Not recognizing food visually
  - Oral agnosia – not recognizing that what is in the mouth is food
  - Oral apraxia – not knowing how to program movements for chewing and swallowing
  - Can result in pocketing and spitting out food, or holding in mouth
- Pharyngeal phase
  - Aspiration (before, during and after)
Management is typically only through compensations

- Dysphagia in dementia is a progressive disorder
- Cognitive deficits preclude patient participating in active rehabilitation
- Compensations change over the course of the disease
- Select strategies appropriate for the problems presented
- These strategies are taught to staff and family
  - The speech-language pathologist attending meals and providing these strategies on an on-going basis is not considered skilled

Typical compensations

- Change how the patient is positioned
  - Upright is best
- Change how the food is presented
  - Small bites and sips
  - Adaptive utensils or finger foods
- Change the food itself
  - Texture
  - Thickened liquids if necessary
  - Thicker is not always better – nectar may be enough
Questions?