Resonance Disorders and Velopharyngeal Dysfunction:
Evaluation and Treatment

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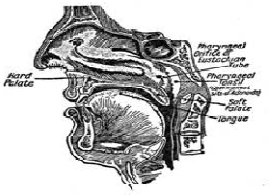


Financial Disclosures

- Employment:
  - Cincinnati Children's Hospital Medical Center
- Royalties
  - Author of the text called *Cleft Palate and Craniofacial Anomalies: The Effects on Speech and Resonance*, Delmar Cengage, 2008.
  - Developer of *Oral and Nasal Listener* (ONL), Super Duper Publications
- Honoraria
  - Seminars at state conferences and other events

Non-Financial Disclosure

- Author of the SNAP test for nasometry
- Serve on committees for the American Cleft Palate-Craniofacial Association
- Serve on various advisory boards

Seminar Outline

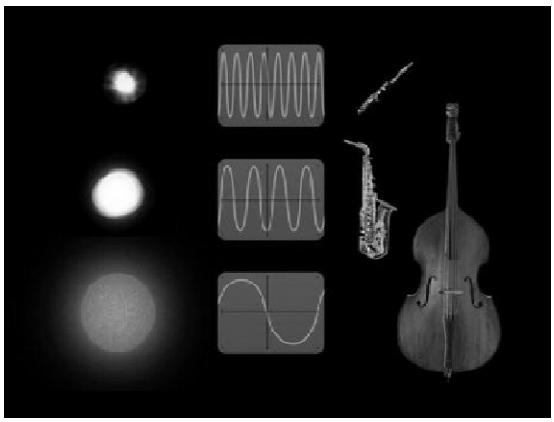
Resonance Disorders and Velopharyngeal Dysfunction

- Normal resonance
- Resonance disorders
- Normal velopharyngeal function
- Velopharyngeal dysfunction (VPD)
  - Velopharyngeal insufficiency (VPI)
  - Velopharyngeal incompetence (VPI)
  - Velopharyngeal mislearning
- Effects of CLP/VPI on speech and resonance

Evaluation and Treatment

- Evaluation
  - Perceptual evaluation
  - Intra-oral evaluation
  - Instrumental evaluation
- Treatment of VPI
  - Surgical procedures
  - Prosthetic devices
- Speech therapy
- Referrals

Normal Resonance



What is resonance for speech?

- Modification of the sound that is generated from the vocal cords thru selective enhancement of frequencies
- Provides the *quality* of perceived sound during speech

What determines resonance for speech?

- Size and shape of the **resonating cavities**
  - pharyngeal cavity
  - oral cavity
  - nasal cavity
- Function of the **velopharyngeal valve**

Size and Shape of Cavities

- Shorter/smaller cavities: enhance higher formants
- Longer/larger cavities: enhance lower formants

Size and Shape of Cavities

Resonance is affected by the following:

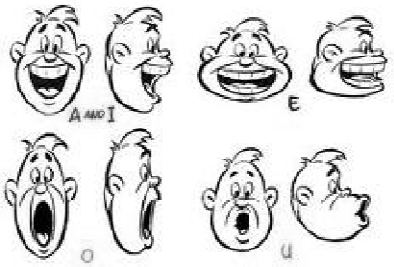
- Length and volume of pharynx
- Size and shape of oral cavity
- Configuration of nasal cavity

Size and Shape of Cavities

- Differences between
  - children and adults
  - men and women
  - tall people and short people
- Makes voice quality unique to individual

Resonance and Vowels

- Vowels are “resonance sounds”
- They are produced by changing the size and shape of the oral (resonating) cavity

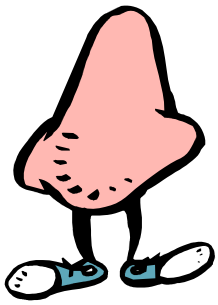


Resonance Disorders

- Hypernasality
- Hyponasality (denasality)
- Cul de sac resonance
- Mixed resonance

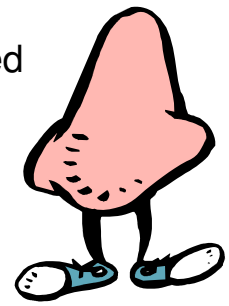
Hypernasality

- Too much sound resonating in the nasal cavity
- Usually due to VPI or fistula
- Most perceptible on vowels



Hypernasality

- Voiced oral consonants become nasalized (m/b, n/d, etc.)
  - Obligatory distortion
- Other consonants may be substituted by nasals
  - Compensatory production



Hyponasality

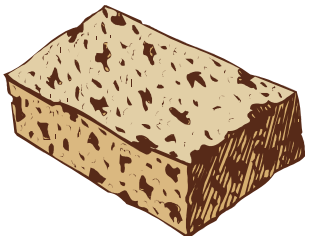
- Not enough nasal resonance on nasal sounds (m, n, ng)
- Due to nasal obstruction
- Nasal phonemes sound similar to oral cognates (b/m, d/n, g/ng)
- Also noticeable on vowels

Cul de Sac Resonance

- Sound resonates in a cavity (oral, pharyngeal or nasal), but cannot get out
- Due to blockage in the vocal tract

Cul de Sac Resonance

- Voice sounds muffled and low in volume
- Sound is absorbed (like a sponge) in the cavity



Cul de Sac Resonance
Types and Causes

- **Oral** cul de sac resonance
- **Nasal** cul de sac resonance
- **Pharyngeal** cul de sac resonance

Oral
Cul de Sac Resonance

- Sound is mostly in the oral cavity
- Due to small oral cavity size or small mouth opening (microstomia)
- Parents describe speech as “mumbling” (which is not opening the mouth very much)

Nasal
Cul de Sac Resonance

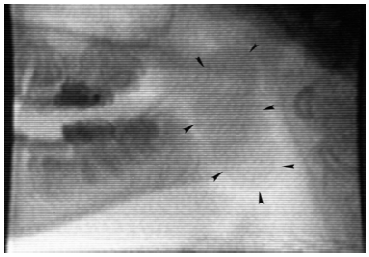
- Sound is mostly in the nasal cavity
- Due to VPI and nasal obstruction from:
  - a deviated septum
  - stenotic nares
  - maxillary retrusion
- Common with cleft palate and craniofacial anomalies

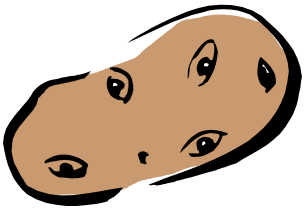
Pharyngeal
Cul de Sac Resonance

- Sound is mostly in the pharynx
- Common in patients with very large tonsils

Pharyngeal
Cul de Sac Resonance

- Has been called “potato-in-the-mouth” speech
- Enlarged tonsils are the “potatoes”





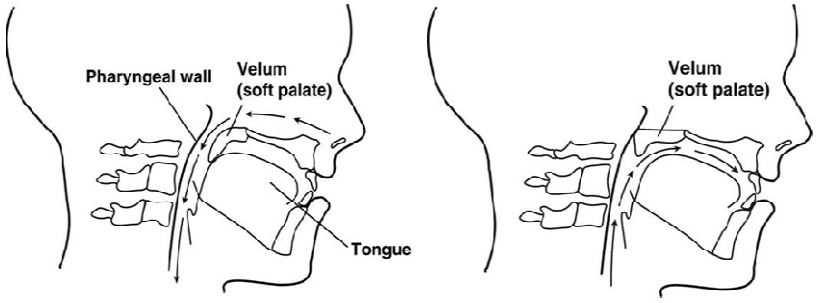
Pharyngeal
Cul de Sac Resonance

- Enlarged tonsils block sound transmission to oral cavity

Mixed Resonance

- Hypernasality and/or nasal emission on oral sounds and hyponasality on nasal sounds
- Due to:
  - VPI and obstruction
  - Apraxia

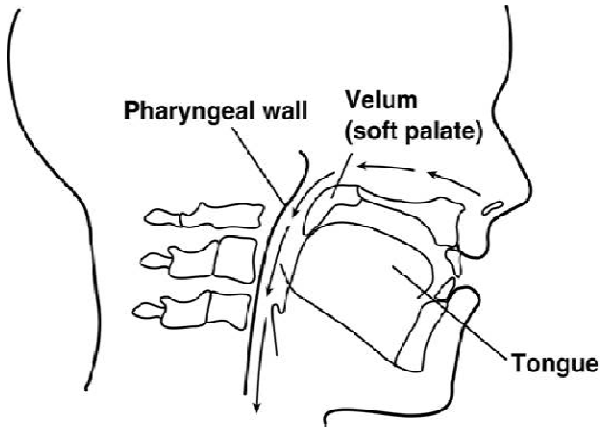
Normal Velopharyngeal Function



Structures Active in VP Closure

- Velum (Soft Palate)
- Lateral Pharyngeal Walls (LPWs)
- Posterior Pharyngeal Wall (PPW)

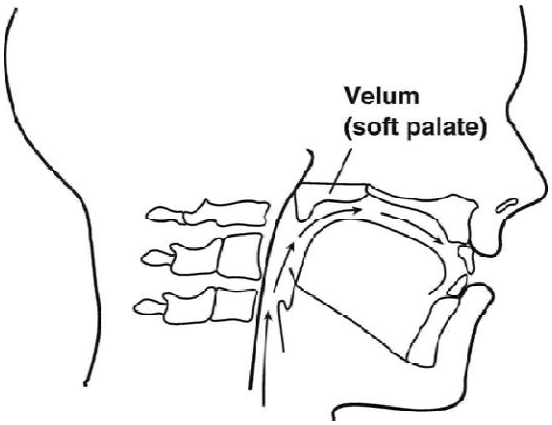
Velum: Rest



Velum (Soft Palate)

- Moves in a superior and posterior direction
- Has a type of “knee” action
- Moves toward the posterior pharyngeal wall

Velum: During Speech

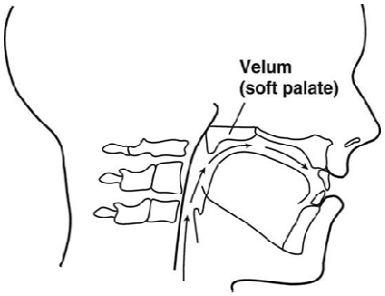


Physics and Flow

- Water (and air) flow in a forward direction until something stops it
- An obstructing object will redirect the flow

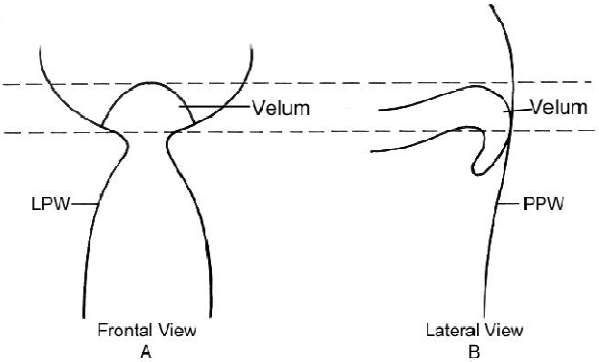
Velopharyngeal Valve and Flow

- Due to the physics of airflow, even a small opening will be symptomatic for speech.



Lateral Pharyngeal Walls (LPWs)

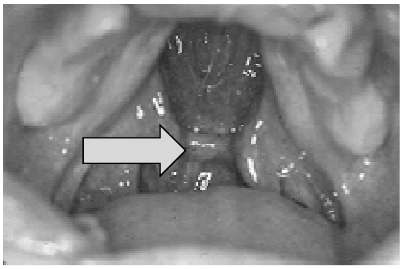
- Move medially to close against the velum or in some cases, behind the velum

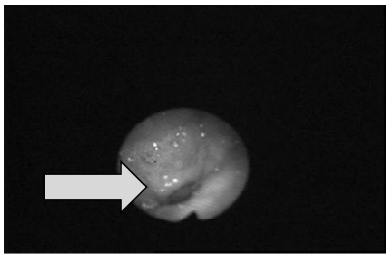


Posterior Pharyngeal Wall (PPW)

- Has slight anterior movement toward the velum
- In some speakers, there's a bulge called a Passavant's ridge (formed by muscle contraction)

Passavant's Ridge





VP Valve during Speech

- Velopharyngeal valve is closed for oral sounds
  - Most consonants (air pressure sounds)
  - All vowels (resonance sounds)
- Velopharyngeal valve is open for nasal sounds (m, n, ng)

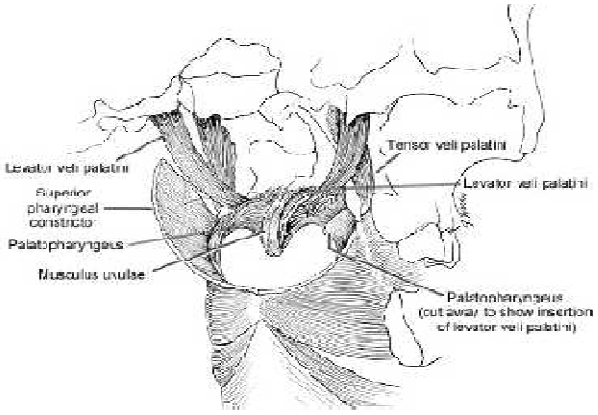
Purpose of VP Valve

- Directs transmission of sound energy and air flow in the oral and nasal cavities during speech

Muscles of VP Closure

- Levator veli palatini (velar “sling”)
- Superior constrictor (pharyngeal ring)
- Palatopharyngeus (post. faucial pillar)
- Palatoglossus (ant. faucial pillar)
- Musculus uvulae (bulge on nasal surface)

Muscles of VP Closure



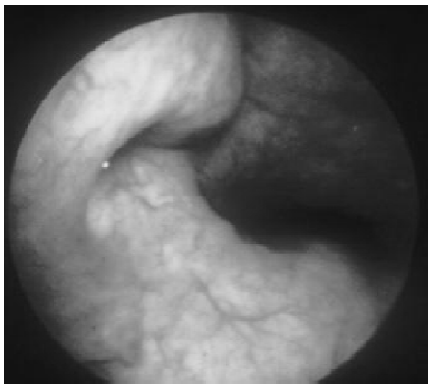
Motor Nerves of VP Function

- Glossopharyngeal (IX)
- Vagus (X)
- Accessory (XI)
- Trigeminal (V)
- Facial (VII)

Sensory Nerves of Velum

- Vagus (X)
- Glossopharyngeal (IX)

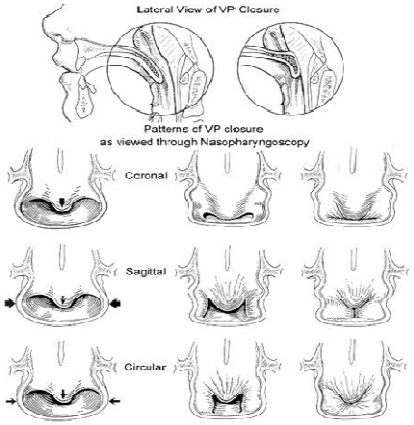
Normal VP Closure
(Nasopharyngoscopy)



Variations in VP Closure

- Coronal Pattern
  - Due mostly to velar movement
- Sagittal Pattern
  - Due mostly to LPW movement
- Circular Pattern (with and without Passavant's ridge)
  - All structures move and close like a purse string

Patterns of Closure

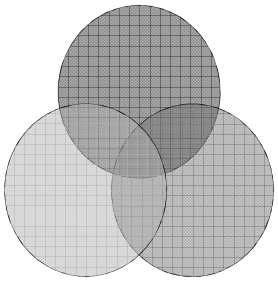


Variations in VP Closure

- Non-Pneumatic:
  - gagging, vomiting, swallowing
- Pneumatic:
  - Positive (+) pressure: blowing, whistling, speech
  - Negative (-) pressure: sucking, kissing

Normal Velopharyngeal Function

Learning (Articulation)



Anatomy (Structure) **Physiology (Movement)**

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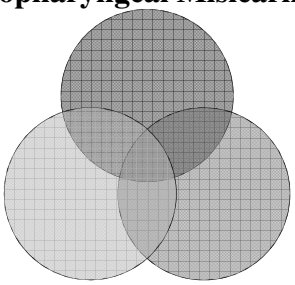
Velopharyngeal Dysfunction

Articulation/Speech Learning
(Velopharyngeal Mislearning)



Anatomy
(Velopharyngeal Insufficiency)

Physiology
(Velopharyngeal Incompetence)

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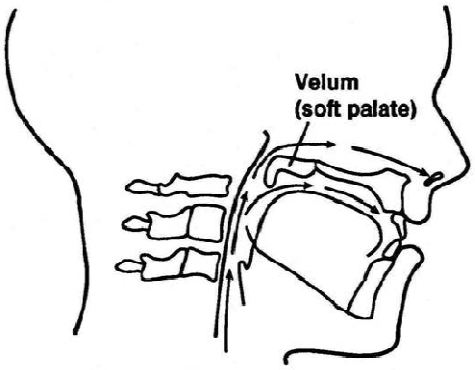
VPI: Velopharyngeal Insufficiency and Incompetence

- Velopharyngeal insufficiency- abnormal structure
- Velopharyngeal incompetence- abnormal neurophysiology

Velopharyngeal Insufficiency

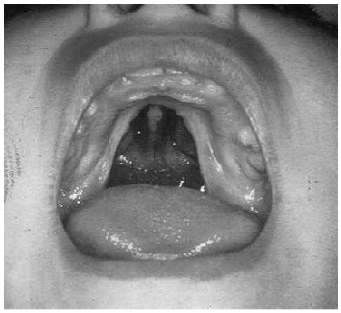


VP Insufficiency

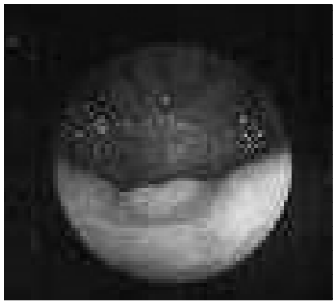
- History of cleft palate
- Submucous cleft palate (overt or occult)
- Short velum or deep pharynx (cranial base anomalies)
- Irregular adenoids
- Enlarged tonsils

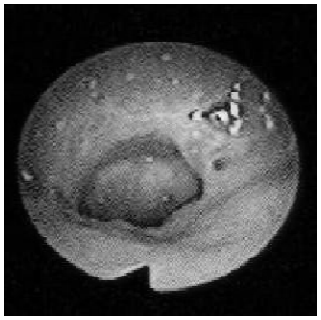
History of Cleft Palate

- Velum may be too short following repair
- Velum may have a notch on posterior nasal surface



Submucous Cleft Palate
Nasal Surface





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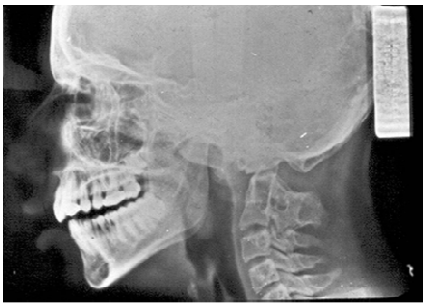
Deep Pharynx

- Can be due to cranial base or cervical spine anomalies (i.e., Klippel-Feil syndrome or craniosynostosis)



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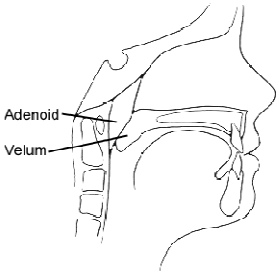
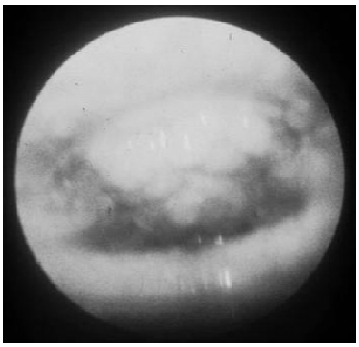
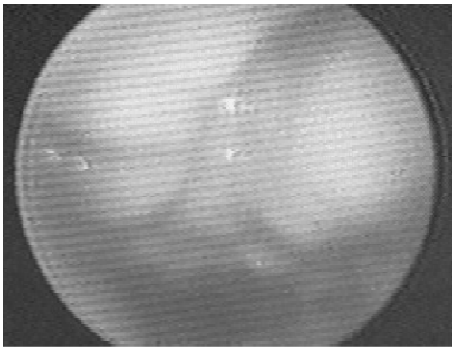
Adenoids

- Positioned in usual site of VP contact
- Closure is velo-adenoidal in kids
- Normal VP closure requires a tight seal
- Adenoid protrusion or indentation can affect closure



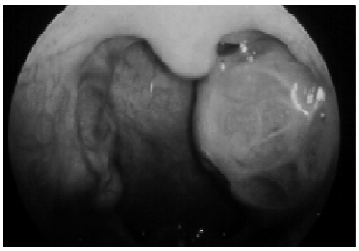
Irregular Adenoids



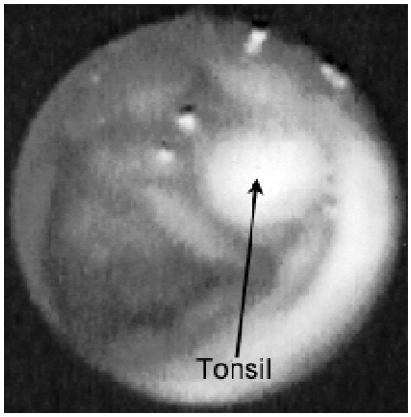


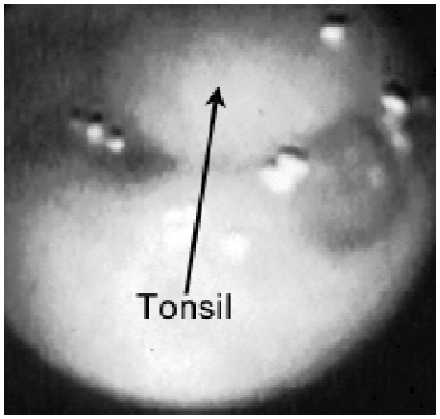
Enlarged Tonsils

- Can extend into pharynx, interfering with LPW and velar movement or preventing a tight VP seal



Nasopharyngoscopy of Tonsil





VP Insufficiency
Following Surgery or Treatment

- Adenoidectomy
- Maxillary advancement
- Treatment of nasopharyngeal tumors

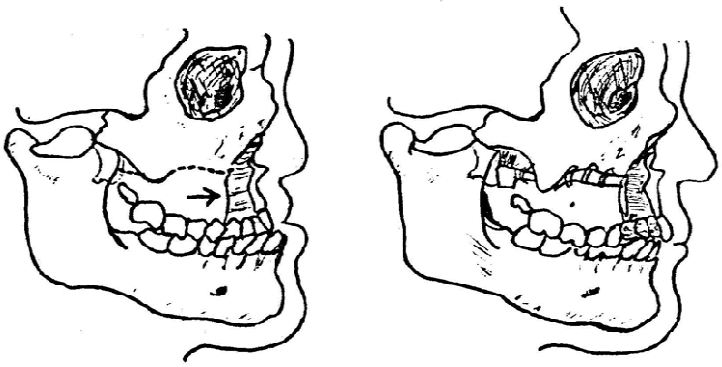
Adenoidectomy

- Sudden increase in the nasopharyngeal dimension can cause VPI
- Often temporary and resolves within 6 weeks
- Permanent VPI is a risk, especially with history of cleft or submucous cleft

VPI Post Adenoidectomy

- Caused by a change in the structure
- **Speech therapy CANNOT change structure**
- **Exercises don't work** because the problem is not the muscles
- **VPI post-adenoidectomy requires surgical intervention by a surgeon who specializes in clefts and VPI**

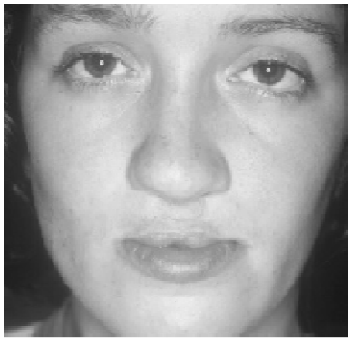
Le Fort I Maxillary Advancement



Maxillary Advancement

- Done surgically or through distraction
- Corrects Class III malocclusion and midface retrusion
- Improves aesthetics and articulation (obligatory distortions)
- Often done for patients with history of cleft

Pre Maxillary Advancement



Post Maxillary Advancement

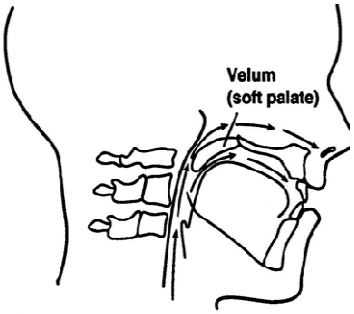
Post Maxillary Advancement

- Moving maxilla forward also moves velum forward
- Velum may stretch and lengthen; LPW movement may increase
- VPI is a risk, especially in patients with history of cleft or submucous cleft

Treatment for Oral Cavity of Nasopharyngeal Tumors

- Radiation therapy shrinks abnormal and surrounding normal tissue
- Ablative surgery removes tissue
- Both increase nasopharyngeal space, making closure more difficult

Velopharyngeal Incompetence

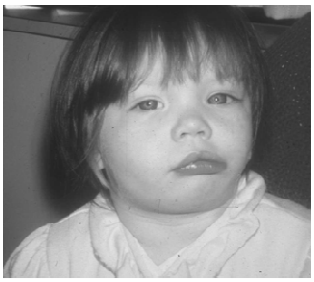


Causes of VP Incompetence

- Cranial nerve damage
- Central neurological dysfunction
  - Injury or neuromuscular disease

Cranial Nerve Damage

- Can cause velar paralysis or paresis
- Often unilateral
- Affected side of velum droops, causing a lateral gap
- Uvula points to unaffected side
- Common in hemifacial microsomia



Central Neurological Dysfunction

- Injury
  - Head trauma/traumatic brain injury
  - Cerebral palsy
  - CVA/stroke
- Neuromuscular Disease
  - Myasthenia gravis, muscular dystrophy, etc.

Central Neurological Dysfunction

May cause:

- Hypotonia
- Dysarthria
- Apraxia of speech

- All of these can cause VP incompetence

Hypotonia

- Can cause poor or weak velar and pharyngeal movement
- Pharyngeal hypotonia is common with velocardiofacial syndrome)

Dysarthria

- Affects all subsystems of speech:
  - Respiration
  - Phonation
  - Articulation
  - **Velopharyngeal function**

Characteristics of Dysarthria

- Slurred, imprecise articulation
- Poor breath support
- Decreased volume
- Slow rate
- **Hypernasality- common**

Characteristics of Dysarthria

- Poor movement of anterior structures (for articulation) and posterior structures for (VP closure)
- Weakness increases with fatigue
- Gradual onset of dysarthria with hypernasality is often the first symptom of a neuromuscular disease

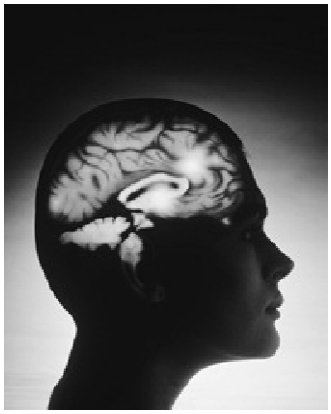
Apraxia of Speech

- Motor speech disorder causing difficulty combining and sequencing motor movements
- Affects coordination of subsystems of speech:
  - Articulation
  - Phonation (voiced/voiceless errors)
  - **Velopharyngeal function** (oral/nasal errors)

Apraxia of Speech

- Poor coordination, timing, and duration of VP closure
- Velum goes up inappropriately for nasal sounds and down for oral sounds
- Inconsistent hypernasality/hyponasality

Velopharyngeal Mislearning



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Velopharyngeal Mislearning

Causes:

- **Hearing Loss/Deafness**
- **Secondary to VPI:** Learned compensatory productions secondary to VPI
- **Secondary to Mislearning:** Misarticulations that *cause* nasal emission unrelated to a VPI

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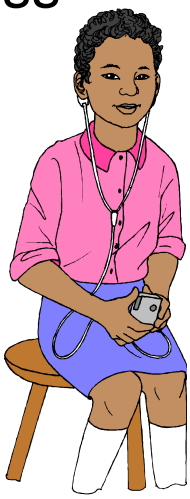
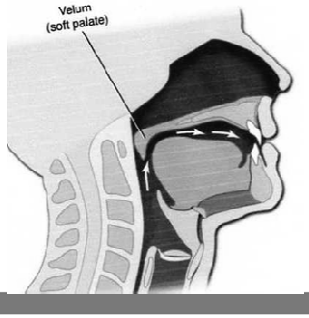
Hearing Loss/Deafness

- Need auditory feedback because there is no tactile-kinesthetic feedback of VP movement
- Results in a mixture of hyper- and hyponasality



"Hypernasality" due to Misarticulations

- Nasalization of vowels
  - Back of tongue too high on vowels
  - Can be phoneme-specific on the high vowel /i/



“Hypernasality” due to Misarticulations

- Substitution of nasal consonants for oral consonants (i.e., ng/l, ng/r)

Nasal Emission due to Misarticulation

- Due to pharyngeal or posterior nasal fricatives
- Causes *phoneme-specific nasal air emission* (PSNAE)
- Usually occurs on sibilants, particularly s/z
- Child is usually stimulable

Recommendations for VP Mislearning

- Speech therapy because this is a speech sound (articulation) disorder
- Surgery is NOT indicated!!!
- Differential diagnosis is very important!

Effects of Cleft Palate and VPI on Speech and Resonance

- Abnormal resonance (sound)
- Nasal air emission (airflow)
- Dysphonia (sound)

Abnormal Resonance due to CLP

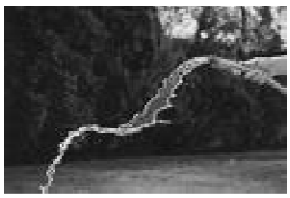
- Hypernasality due to VPI or fistula
- Hyponasality or cul de sac resonance due to blockage

Nasal Air Emission

- Occurs with or without hypernasality
- ***Air*** leaks through the valve
- Occurs on high pressure consonants, particularly ***voiceless consonants***

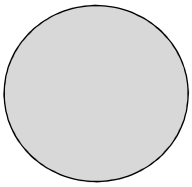
Types of Nasal Emission

- Large opening
- Small opening
  - Nasal Rustle (Turbulence)



Nasal Emission with Large Opening

- No impedance to airflow
- Soft, low intensity sound
- Affects articulation and utterance length



Nasal Emission
with Large Opening

Can also cause:

- Weak or omitted consonants
- Short utterance length
- Nasal grimace
- Compensatory articulation productions

Weak or Omitted Consonants

- Greater the nasal air emission, the weaker the consonants will be due to loss of oral air pressure
- Affects pressure-sensitive consonants

Short Utterance Length

- Leak of air pressure causes need to increase respiratory effort and take more frequent breaths
- Utterance length becomes shortened

Nasal Grimace

- Contraction seen at side of nose or at nasal bridge
- Overflow muscle reaction in attempt to close VP valve

Compensatory Productions
for Palatal Fistula

- Production is behind the fistula, before air can escape through it.

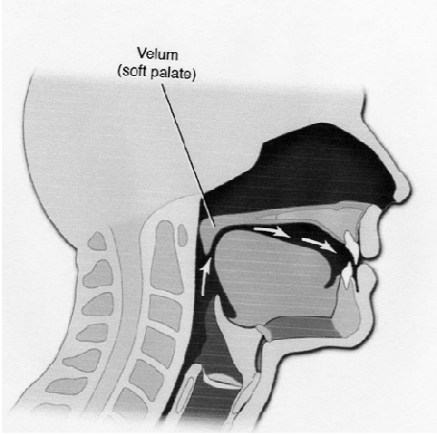
Plosives (Stops)

- **Velar** plosive (backing of anterior sounds)

Fricatives

- **Velar** fricative

Velar Fricative



Compensatory Productions
for VPI

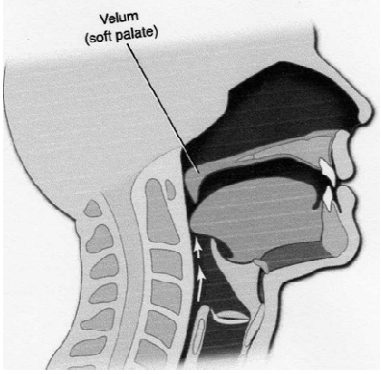
Plosives (Stops)

- **Pharyngeal** plosives
- **Glottal** stops

Fricatives

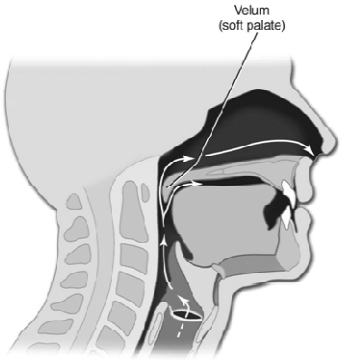
- **Pharyngeal** fricatives
- Posterior **nasal** fricatives
- **Glottal** fricative (/h/)
- **Nasal** sniff

Pharyngeal Plosive



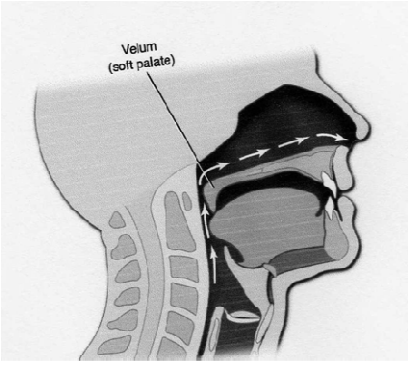
Glottal Stop

Can be Co-Articulated

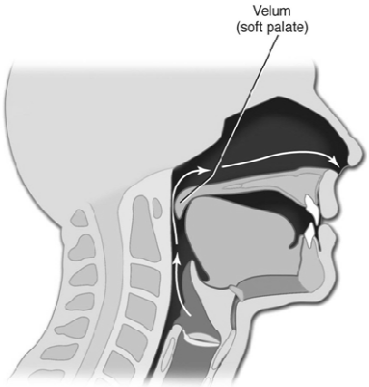


7.12 Glottal stop with coarticulated /+/ placement

Pharyngeal Fricative



Posterior Nasal Fricative



7.11 Posterior nasal frictive

Posterior Nasal Fricative

- Back of tongue articulates against velum
- Air pressure forced into pharynx
- VP valve opens for release of air pressure
- Causes phoneme-specific nasal air emission (PSNAE)

Glottal Fricative (/h/)

- Substituted for oral fricatives

Nasal Sniff

- Occurs as a substitution for sibilants, particularly /s/
- Usually occurs in the final word position

Compensatory Productions
for VPI

- Manner of production is maintained
- Placement is in pharynx to take advantage of air flow
- VP valve will be opened during production, so there will be associated nasal emission

Compensatory Productions
for VPI

- Nasal emission is due to production, so persists, even after surgery for VPI
- Speech therapy is needed postoperatively to correct placement (which will eliminate nasal emission)

Nasal Emission
with Small Opening

- Characterized by an inconsistent nasal rustle (nasal turbulence)
- Due to *bubbling of secretions* as air forced through the small opening
- Distortion is loud and distracting
- Has no effect on strength of consonants or utterance length
- Usually does not occur with hypernasality

Nasal Emission
with Small Opening

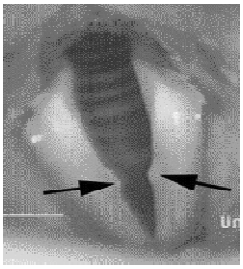
- Patient can usually close with effort
- Opening increases with motoric demands and fatigue
- Can correct “in therapy”- but child will not be able to maintain it
- Therefore, even a small structural gap will require surgical correction

Dysphonia

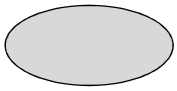
- Hoarseness
- Breathiness
- Abnormal pitch

Dysphonia

- Vocal cord nodules due to strain in the vocal tract with VPI
- Laryngeal anomalies with craniofacial syndromes
- Compensatory strategy
  - Breathiness and low volume mask hypernasality and nasal emission



Prediction of Gap Size
based on perceptual features



→Hypernasality, *inaudible* nasal emission, weak consonants, short utterance length, compensatory productions

→Hypernasality, *audible* nasal emission, weak consonants, may have compensatory productions

→Possibly mild hypernasality and audible nasal emission

→Normal resonance, but inconsistent nasal rustle (turbulence)