Anatomy and Physiology of the Articulatory System

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2013-2014

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Agenda

• Overview of the speech production mechanism

• Anatomy of the articulatory system
  • Skeletal framework
  • Musculature

• Physiology of the articulatory system
Speech production - overview

- Anatomically and physiologically, it is divided into three components:
  - Respiration
  - Phonation
  - Articulation

- In theory, these components are independent of each other
Speech production - overview

• These systems all have their own biological (B) and (S) speech functions

• Respiratory system
  • B: breathing
  • S: “power supply” for speech production

• Phonatory system
  • B: a valving system in the throat
  • S: sound generation

• Articulatory system
  • B: mastication, deglutition, gustation
  • S: resonance, sound generation
The articulatory system

- Everything above the larynx, = supralaryngeal system
- Complicated; quite irregular
- Involves the entire skull (cranium) and face
- Shape of articulatory system is flexible
- Movement is relatively fast
- Few superficial structures. Most structures lie deep inside
- What is the meaning of “articulation”?
Major functions

• Biological function
  • Mastication
  • Deglutition
  • Gustation
  • Digestion

• Speech function
  • Articulation, resonance
  • Sound generation
The vocal tract

• 4 cavities in the vocal tract:
  • Buccal cavity
  • Oral cavity
  • Nasal cavity
  • Pharyngeal cavity
• Definitions

• Function of vocal tract
  • Resonance
  • Articulation
Cavities of the articulatory system

- **Buccal cavity**
  - Anterior: two lips
  - Posterior: two teeth
  - Size variable

- **Oral cavity**
  - Anterior: two teeth
  - Posterior: anterior faucial pillar
  - Superior: hard and soft palates
  - Inferior: tongue

- **Nasal cavity**

- **Pharyngeal cavity**
  - From base of skull to esophagus
  - 3 divisions
    - nasopharynx
    - oropharynx
    - laryngopharynx
The oral cavity
The oral cavity

- Anterior faucial pillars
- Posterior faucial pillars
- Boundary:
  - Floor: tongue
  - Anterior: teeth
  - Posterior: anterior faucial pillars
  - Roof: hard palate, soft palate & uvula
The nasal cavity
The nasal cavity

- Shape relatively fixed
- Lined with mucous membrane (soft, warm, and pliable)
- Inferior nasal concha (turbinate)
- Nasal septum
The pharyngeal cavity

- A musculotendinous tube
- A constrictor
- Peristalsis: wave-like contraction for movement of food bolus
- Inferiorly connecting to esophageal opening (UES) (cricopharyngeus muscle)
- Eustachian tube
  - Where is it?
  - Function
The pharyngeal cavity

- Nasopharynx
  - Base of skull - soft palate
- Oropharynx
  - Soft palate - hyoid bone
- Laryngopharynx
  - Hyoid bone - cricoid cartilage
The skeletal framework

• The skull
  • Cranial bones - forming the cranium, housing the brain
  • Facial bones - contribute to the facial configuration
The skull - anterior view

- Orbits
- Nasal opening
- Supra- and infra-orbital margins
- Frontal bone, glabella
- Zygoma (cheek)
- Upper and low jaws
- Nasal bone
- Nasal septum
The skull - lateral view

- TMJ (Temporomandibular joint)
- Upper and lower jaws
- Parietal bones
- Temporal bones
- Anterior nasal spine
- Zygomatic bones
The skull - superior view (cut)

- Ethmoid bone, crista galli
- Sphenoid bone, sella turcica
- Foramen magnum
- Occipital bone
- Superior occipital protuberance
The skull - inferior view

- Hard palate (maxillary bone + palatine bone)
- Posterior nasal spine
- Foramen magnum
- Occipital condyles
- Occipital bone
- Zygomatic bones
- TMJ
- Temporal bones (mastoid process)
The face - anterior view
The face - lateral view

temporal bone, squamous part
superior temporal line
inferior temporal line

parietal bone

squamosal suture
occipital bone
lambdoid suture

external acoustic meatus
mastoid process
condyle
zygomatic process
zygomatic bone

coronal suture
frontal bone
temporal line

lacrimal bone
sphenoid bone
nasal spine
maxilla
ramus
mandible
The mandible

- A.k.a. lower jaw
- The only freely moving bone in the skull
- TMJ - a bi-condyloid joint
- Teeth do not belong to mandible
- Movements: rotational & translational
- Closely related to tongue movement
The mandible

- Ramus
- Body
- Angle
- Alveolar process
- Coronoid process
- Condyloid process
- Mandibular notch
- Oblique line
- Mylohyoid line
- Mental & mandibular foramen
Occlusion

• Occlusion - relative positioning of the mandible and maxillary bones
• Malocclusion
  • May be caused by relative sizes of the mandible and the upper jaw
  • May be caused by imperfection of TMJ

• Angle’s Classification:
  • Class I: normal occlusion
  • Class II: retracted mandible
  • Class III: protruded (prognathic) mandible
Occlusion
The hard palate

- Anterior 3/4: formed by palatine process of maxillary bones
- Posterior 1/4: formed by horizontal process of palatine bones
- Incisive foramen
- Median suture
- Alveolar process
- Soft palate (more later)
The hard palate
Speech muscles

- Divided into different regions:
  - Labial
  - Lingual
  - Mandibular
  - Palatal
  - Pharyngeal
The lips

• Biological function
• Speech function
  • bilabial sounds
    • /p, b/, /f, v/, /w/, /u/ etc.
• A sphincter
• Corner of the mouth
• Orbicularis oris superioris & inferioris
• No definite shape and size
• Muscle fibers in circular fashion
The lips
The lips
The lips

- Other muscles assisting the lips:
  - Buccinator
  - Risorius
  - Levator labii superioris
  - Depressor labii inferioris
  - Levator labii superioris alaeque nasi
  - Levator anguli oris
  - Depressor anguli oris
  - Zygomaticus major
  - Zygomaticus minor
  - Mentalis
  - Platysma
The teeth

- Location, shape, and size relatively fixed
- Lower teeth move with mandible
- Biological function
  - Mastication (physically break down food, increase surface area for digestion)
  - Defense (in lower animals)
- Speech function
  - Dental sounds
  - $/\emptyset, \delta/, /f, v/, /s, z/, /\flat, \emptyset/$ etc.
The tongue

• The fastest moving articulator
• Shape and location of tongue can be changed by intrinsic and extrinsic tongue muscles
• Major functions: to change the resonance property of the vocal tract
• Biological function: gustation, tactile, ...
The tongue

- Oral/palatal part:
  - Tip
  - Blade
  - Dorsum
- Pharyngeal part:
  - Root
- Tongue body
- Glossectomy - surgical removal of tongue
Gustation

- Biological functions
  - Gustation (taste buds)
  - Mastication

- Speech function
  - Lingual sounds, very important as many sounds are involved with tongue tip and blade
  - (/l, n, d, t, k, g, r, w, u, i, s, z, .../)
Intrinsic tongue muscles

- Superior longitudinal tongue muscle
- Inferior longitudinal tongue muscle
- Vertical tongue muscle
- Transverse tongue muscle
Intrinsic tongue muscles

• Mainly to change the configuration of tongue (tension, shape, length, tongue tip curling, etc.)

• Particularly important in /s, z/, /r/, /l/
Extrinsic tongue muscles

- Genioglossus
- Styloglossus
- Palatoglossus
- Hyoglossus
Extrinsic tongue muscles

- Mainly used to change location of tongue
- Fronting, backing, elevation, depression
Tongue movement and tongue muscles

- Tongue fronting:
  - E.g. /ə/, /ʊ/, /i/
  - Genioglossus (posterior fibers) (GGP) (+ jaw movement)

- Tongue tip up
  - E.g. /s/, /l/, /n/, /t/
  - GGP + superior longitudinal

- Tongue dorsum back and up
  - E.g. /u/, /w/, /k/
  - Styloglossus (+ palatoglossus)
Tongue movement and tongue muscles

- Tongue surface groove
  - E.g. /s/
  - Verticalis lingualis
- Tongue tip curling up
  - E.g. /l/, /r/
  - Superior longitudinal
- Tongue lowering & flattening
  - E.g. /a/
  - Hyoglossus + inferior longitudinal
- Tongue deviation
  - E.g. licking the corner of mouth
  - Superior longitudinal
The jaw

- Biological function
  - Mastication

- Speech function
  - Very important as many other articulators move with the mandible

- Temporomandibular joint (TMJ)
Mandibular elevators

- Mandibular Elevators
  - Temporalis
  - Masseter
  - Medial / Internal pterygoid muscle
Temporalsis m.
Masseter m.
Masseter m.
Medial pterygoid m.
Mandibular depressors

- Digastricus
- Mylohyoid
- Geniohyoid
- Lateral / External pterygoid muscle
Mandibular depressors
Lateral pterygoid m.
Lateral pterygoid m.
Jaw involvement in speech

• Low vowels vs. high vowels

• Consonants: bilabial, alveolar, velar

• Tongue moves as the mandible moves; tongue and mandible move as one system
The soft palate
The soft palate

- Soft palate forms the posterior 1/3 of the entire palate
- Formed by muscles
- An important part of the velopharyngeal (VP) port
- VP port = gateway to nasal cavity, controls nasality
  - Open VP port, nasal resonance
- Cleft palate
Cleft palate

• Nasals vs. oral sounds
• Nasalized vowels
• Question: Nasalized or non-nasalized during a cold?
Palatal muscles

- Tensor veli palatini m.
- Levator veli palatini m.
- Uvula m.
- Palatoglossus m.
  - Anterior faucial pillars
- Palatopharyngeus m.
  - Posterior faucial pillars
Palatal muscles
Palatal muscles
Palate movement
Pharyngeal constrictors
Pharyngeal constrictors

- Superior pharyngeal constrictors
  - Pterygopharyngeus m.
  - Buccopharyngeus m.
  - Mylopharyngeus m.
  - Glossopharyngeus m.
- Middle pharyngeal constrictors
  - Chondropharyngeus m.
  - Ceratopharyngeus m.
Pharyngeal constrictors

- Inferior pharyngeal constrictors
  - Thyropharyngeus m.
  - Cricopharyngeus m.
- Stylopharyngeus m.
- Salpingopharyngeus m.
- Palatopharyngeus m.
Links

• **More pictures** (courtesy to Loyala University Medical Education Network)

• **My site**

• And many more...
THE END