Mouth and Airway Development, Disorders, Assessment, and Treatment: Birth to Age 7

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Financial and Non-Financial Relationships

Financial: Diane Bahr is the author of two books *Oral Motor Assessment and Treatment: Ages and Stages* (Allyn & Bacon, 2001) and *Nobody Ever Told Me (or My Mother) That! Everything from Bottles and Breathing to Healthy Speech Development* (Sensory World, 2010) for which she receives royalty payments. She is also the co-owner of Ages and Stages, LLC, as well as a presenter for TalkTools, Speech Therapy PD, and Northern Speech Services for which she is paid.

Non-Financial: Diane Bahr is a member of the American Speech-Language-Hearing Association, the International Association of Infant Massage Instructors, and the International Association of Orofacial Myology.

Financial: Kristie Gatto is the author of three books Understanding the Orofacial Complex: the Evolution of Dysfunction (Outskirts Press, 2016), Understanding the Orofacial Complex – Muscle Manual (Outskirts Press, 2014), and Sam the Super Chewer, Eats (Mindstir Media, 2016) for which she receives royalty payments. She is also the owner of The Speech and Language Connection in Houston, as well as an instructor for the International Association of Orofacial Myology for which she is paid.

Non-financial: Kristie Gatto is a member of the American Speech-Language-Hearing Association, the President of the International Association of Orofacial Myology, a Board of Directors member for the American Academy of Private Practitioners in Speech Pathology and Audiology, and a member of the Community Advisory Board at the University of Houston.

Author Information

Diane Bahr is a speech-language pathologist, feeding therapist, published author, international speaker, former university instructor, mother, and grandmother with over 35 years of experience working with children and adults, their families, their therapists, and their doctors. Diane wants all children (and adults) to have the best possible feeding, speech, and mouth development/function. This is accomplished by educating parents, professionals, and consumers in the best possible practices.

Kristie Gatto is a certified orofacial myofunctional therapist, feeding therapist, speech-language pathologist, published author, international speaker, and private practice owner in the greater Houston area. She has focused her clinical skills on treating children with issues in feeding, dysphagia, deglutition, oral sensory aversion, orofacial myology, and swallowing-related disorders, as well as articulation, phonological processing, apraxia, and early childhood intervention. Kristie is the author of two books on muscle function, one children's book, and an instructor for the International Association of Orofacial Myology.

Learner Outcomes

1. Discuss the current research literature on mouth and airway development, function, disorders, assessment, and treatment
2. Describe typical mouth and airway development/function and explain disruptions in mouth and airway development/function
3. Describe and explain assessment and treatment of disruptions in mouth and airway development/function

Reasons for Reviewing this Literature

- There is an increasing body of literature on this topic (large number of journal articles/resources reviewed)
- The literature emanates from many disciplines and researchers throughout the world (e.g., speech-language pathology, orofacial myology, dentistry and orthodontics, otolaryngology, lactation, etc.)
- The relationship between mouth and airway problems seems to greatly impact the assessment and treatment of feeding, speech, and mouth development/function in babies and young children
- Need to find the best available evidence on prevention, elimination, and habilitation of mouth and concomitant airway problems in children birth to age 7 years
- Early assessment and intervention is a common theme in the literature, yet limited professional education and assessment/treatment protocols seem available
- What are the next steps in the development of professional education, as well as systematic assessment and treatment protocols and practice? Could a comprehensive literature review be a good place to begin?

Examples of "Levels of Evidence" Rating Scales

(Robey, 2004, p. 3; ASHA, 2004, p. 2) in Bahr & Banford, 2012

"Example Levels of Evidence" (Robey, 2004, p. 3)

1A: "Meta-analysis of multiple well-designed controlled studies"

1: "Well-designed randomized controlled trials"

2: "Well-designed non-randomized controlled trial (quasi-experiments)"

3: "Observational studies with controls (retrospective studies, interrupted time-series studies, case-control studies, cohort studies with controls)"

4: "Observational studies without controls (cohort studies without controls and case series)"

"Levels of Evidence for Studies of Treatment Efficacy" Example (ASHA, 2004, p. 2)

Ia: "Well-designed meta-analysis of >1 randomized controlled trial"

Ib: "Well-designed randomized controlled study"

IIa: "Well-designed controlled study without randomization"

IIb: "Well-designed quasi-experimental study"

III: "Well-designed nonexperimental studies, i.e., correlational and case studies"

IV: "Expert committee report, consensus conference, clinical experience of respected authorities"

Typical Mouth and Airway Development/ Function

UTERO TO AGE 7 YEARS

In Utero Structure (Gaultier & Guilleminault, 2001; Guilleminault & Huang, in press; Miller, Macedonia, & Sonies, 2006; Page, 2003; Som & Naidich, 2013; University of MN, nd)

- 4th week: Face and oral cavity begin to appear from migration of neural crest cells forming frontonasal, 2 maxillary, and 2 mandibular processes
- 4th to 5th week: Mandible, lower lip, and chin formed and fused
- 5th to 6th week: Lip closure
- 6th week: Nasal and oral cavities separate
- 6th to 10th week: Palatine shelves begin to lower forming the hard palate and the floor of the nasal cavity in the 8th or 9th week
- 7th week: Upper lip and primary palate formed
- 9th week: Cartilaginous facial structure
- 10th to 12th week: Soft palate tissue fuses
- 12th week: Bone begins replacing cartilage to form early cranial base and vault, mandible, and maxilla
- Approximately 50 % of jaw and tongue growth occurs before birth - the jaws are the gateway to the mouth and airway

In Utero Function

(Guilleminault & Huang, in press; Medeiros, 2007; Miller, Macedonia, & Sonies, 2006; Miller, Sonies, & Macedonia, 2003; Silveira, Prade, Ruedell, Haeffner, & Weinmann, 2013; Thach, 2001, 2007)

- 2nd month: Internal oral cavity like skin with sensory receptors for touch, pressure, temperature, pain, etc.
- 3rd to 5th month: Sucking, swallowing, and oral functioning getting organized
- Oral sensory-motor reflexes activated by interactions between tongue, lips, and palate
  - 26-27 weeks: Gag
  - 27-28 weeks: Suckling and Sucking
  - 28 week: Rooting, Phasic Bite, Transverse Tongue
  - 38-40 weeks: Tongue Extrusion
  - 40 weeks: Cough
- Specific timing of sucking and swallowing reflexes develops along with the esophageal reflex
  - Swallows 7 ml of amniotic fluid (AF) per day at 16 weeks
- Lip contact with hand, foot, etc. results in open mouth and tongue protrusion
  - 17-20 weeks: Hand to face movement
  - 28-31 weeks: Finger sucking
  - 34-35 weeks: Coordination of hand to mouth movements
- Fetus sucks and swallows increasing amounts of amniotic fluid until birth (500 ml of AF per day)

Brain Development and Neural Control (Bahr, 2001; de Boysson-Bardies & Vihman, 1991; Connaghan, Moore, & Higashakawa, 2004; Green, Moore, Higashikawa, & Steeve, 2000; Green, Moore, & Reilly, 2002; Green, Moore, Ruark, Rodda, Morvee, & Van Witzenberg, 1997; Kent, 1999; Kent, Osberger, Netsell, & Hustedde, 1987; Moore, Caulfield, & Green, 2001; Moore & Ruark, 1996; Moore, Smith, and Ringel, 1988; Oller & Ellers, 1988; Ruark & Moore, 1997; Rvachew, Slawinski, & Williams, 1996; Steeve, Moore, Green, Reilly, & McMurtrey, 2008; Wilson, Green, Yunusova, & Moore, 2008; Wohlert & Smith, 2002)

- 5 months gestation: Brain has a "full complement of neurons" (Kent, 1999, p. 46)
- Birth: "Neuronal cell formation complete" (Kent, 1999, p. 46)
- 3 months: Dendritic branching more advanced in oral area of motor strip than in speech motor planning area and in right hemisphere compared to left hemisphere
- 6 months: Development peaks in inner language areas of cortex
- 6 to 12 months: Auditory-motor neural circuits for vocalization seem largely established
- 8 to 9 months: Adult-like metabolic activity seen across brain regions (Kent, 1999, p. 46)
- 15 months: Acceleration of cortical synapses and hippocampus maturity provides neural organization for memory; similarity in mandibular movements for reduplicative babbling and earlier developing feeding movements (e.g., chewing), but no similarity between feeding movements and variegated babbling (more complex speech task)
- 2 years: Dendrite branching in Broca's area, and rest of left hemisphere matures assisting speech and language production; cortical control for feeding and speech differentiated (different motor plans)
- 4 years: Peaks in overall brain metabolism and development of outer language cortex
- 6 years: Speech motor planning area more advanced than oral area of motor cortex allowing complex speech and oral sensory- motor tasks

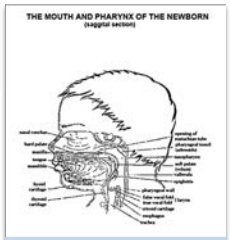
Structures at Birth

(Bahr, 2010; Bosma, 1963a, 1963b; Fayoux, Marciniak, Devisme, & Storme, 2008; Gola, Cheynet, Guyot, Sauvant, & Richard, 2000; Guilleminault & Huang, in press; Morris, 2003; Morris & Klein, 2000; Neskey, Eloy, & Casiano, 2009; Page, 2003)

Full-term newborn babies typically have adequate structures for breathing, feeding, and vocalizing

- Small open space within mouth
- Larynx high in the neck area
- Mouth and throat structures close together (protective)
- Small, slightly retruded lower jaw
- Top and bottom jaws flat appearance (approximately 30% of adult size)
- Hard palate wide "U" shape, approximately ¾ to 1 inch edge to edge across middle
- Hard palate flexible/moveable
- Tongue fills mouth at rest to help maintain palate shape
- Nasal passage is small; nasal turbinates large but decrease in size quickly after birth if no local inflammation
- Full set of sucking pads in cheeks
- Eustachian tubes relatively horizontal
- Head approximately ¼ of baby's length (12% of adult size)

Anthony at birth
Parents granted permission for use



Drawing developed by Artist Betsy True for Suzanne Evans Morris who granted permission for its use.

Functions at Birth

(Bahr, 2010; Bosma, Hepburn, Josell, & Baker, 1990; Colson, Meek, & Hawdon, 2008; Cook, et al., 1957; Da Costa, Van Den Engel-Hoek, & Bos, 2008; Elad et al., 2014; Fisher, Mortola, Smith, Fox, & Weeks, 1982; Geddes, Kent, Mitoulas, & Hartmann, 2008; Genna & Barak, 2010; Gewolb & Vice, 2006; Guilleminault & Huang, in press; Jacobs, Dickinson, Hart, Doherty, & Faulkner, 2007; Kelly, Huckabee, Jones, & Frampton, 2007; Kodali, Chandrasekhar, Bulich, Topulos, & Datta, 2008; Lau, 2015; Lau & Kusnierczyk, 2001; Lundberg & Weitzberg, 1999; Mathew, Clark, Pronske, Luna-Solarzano, & Peterson, 1985; Mizuno & Ueda, 2006; Morris, 2003; Page, 2003; Palmer, 1998; Ramsey & Hartmann, 2005; Rogers & Arvedson, 2005; Schafer & Genna, 2015; Schedin, Norman, Gustafsson, & Frostell, 1996; Vyas, Milner, & Hopkin, 1981; Widstrom et al., 2011)

Oral reflexes present (rooting, suckling, tongue/extrusion, swallowing, phasic bite, transverse tongue, gag)

- Tongue deeply cupped when suckling
- Rooting, tongue, suckling, and swallowing reflexes
  - Seem related to sucking
  - Rooting and suckling come under a baby's control between 1 & 3 months of age
- Phasic bite, transverse tongue, and gag reflexes
  - Seem related to higher level feeding processes
  - Come under a baby's control between 5 & 9 months of age

Hand and Mouth Reflexes present (palmomental, Babkin, grasp)

- **Readiness to feed** is based on functional maturity levels in suck/swallow processing and respiration
- **Nose breathing** crucial for nasal, orofacial, sinus, and thoracic-ventilatory development (nitric oxide present in first few minutes after birth with nasal breathing)
- Resting respiratory rate: 30-40 breaths per minute
- Gums enlarge to assist with latch (likely increased blood supply)
- **Suck-swallow-breathe synchrony**
  - Nutritive suck: Approximately 1 per second
  - Non-nutritive suckle: Approximately 2 per second

Functions at Birth: Breastfeeding (Aniansson et al., 1994; Bahr, 2010; Barlow et al., 1974; Bertrand, 1968; Broad, 1972, 1975; Colson, Meek, & Hawdon, 2008; Cummings, Neifert, Pabst, & Johnston, 1985; Elad et al., 2014; Geddes, Kent, Mitoulas, & Hartmann, 2008; Gerstein, 1994; Hoefer & Hardy, 1929; Horwood & Ferguson, 1998; Jacobs, Dickinson, Hart, Doherty, & Faulkner, 2007; Lau, 2015; Morris, 2003; Nizel, 1975; Page, 2003; Palmer, 1998; Pottenger & Krohn, 1950; Ramsey & Hartmann, 2005; Ransjo-Arvidson et al., 2001; Rey, 2003; Robinson & Naylor, 1963; Saarinen & Kajossari, 1995; Schafer & Genna, 2015; Silveira, Prade, Ruedell, Haeffner, & Weinmann, 2013; Watkins, Leeder, & Corkhill, 1979; Widstrom et al., 2011)

Breastfeeding is Biologically Normal and Superior to Bottle Feeding for Mouth and Airway Development if Done Properly

- Breast drawn deeply into mouth to help maintain hard palate shape
- Balanced intraoral and other pressures (e.g., nasal, sinus, middle ear, pharyngeal, laryngeal) during feeding
- Good suck-swallow-breathe synchronization
- Alternating breasts stimulates/exercises both sides of face, head, and body
- Improved later developing feeding skills such as cup drinking and chewing (Silveira, Prade, Ruedell, Haeffner, & Weinmann, 2013)
- Fewer upper and lower respiratory problems
- Fewer digestive problems (e.g., GERD, belly pain, bowel problems)
- Long-term effects: Better face, jaw, palate, tooth, and speech development

Breastfeeding and Bottle-Feeding are Very Different Processes (Barros de Arruda Telles, Ferreira, Magalhaes, & Scavone-Junior, 2009; Elad et al., 2014; Geddes, Kent, Mitoulas, & Hartmann, 2008; Genna & Sandora, 2017; Gomes, Trezza, Murade, & Padovani, 2006; Hiiemae & Palmer, 2003; Inoue, Sakashita, & Kamegai, 1995; Korfage, Koolsthra, Langenbach, & Van Eijden, 2005a, 2005b; Miller & Kang, 2007; Moral et al., 2010; Nyqvist, Färnstrand, Eeg-Olofsson, & Ewald, 2001; Ratnovsky et al., 2012; Stal, Marklund, Thornell, De Paul, & Eriksson, 2003; Takemoto, 2001; Tamura, Matsushita, Shinoda, & Yoshida, 1998)

BREASTFEEDING (more like open-cup feeding)

- Roots to locate the mother's nipple
- Opens the mouth wide for the breast
- Extends the tongue over the lower lip to grasp the mother's breast
- Draws the mother's nipple/breast deeply into the mouth (which helps maintain the broad "U" shaped roof of the mouth)
- Holds and cups the breast with the front of the tongue while the lips seal against the breast
- Lowers the jaw and the front of the tongue together (with little effort and cheek motion)
- Has more mentalis (everts lower lip) and masseter use than children who bottle-feed
- Has more sucking movements with more and longer pauses than babies who bottle-feed

BOTTLE-FEEDING

- Roots with *Paced Bottle-Feeding*
- Opens mouth enough for the particular bottle nipple
- Extends the tongue over the lower gum while sucking
- Has an even and steady lip latch/flare on the latch area of the bottle nipple
- Tongue cups/grooves around the bottle nipple if rounded shape
- Has more cheek (buccinator) and lip (orbicularis oris) movement than babies who breastfeed
- Has less mentalis (everts lower lip) and masseter use than infants who breastfeed
- Has fewer sucking movements with fewer and shorter pauses than babies who breastfeed

Sensory-Motor Development (Alexander, 1987; Ayers, 1979; Bahr, 2001; B. Bobath, 1971; K. Bobath, 1971; Fisher, 1991; Oetter, Richter, & Frick, 1995; Morris; 1985, 1987; Weisz, 1938)

- The central nervous system controls stability and resulting mobility in the body
- Dynamic stability in the body is needed for adequate mobility (develops proximal to distal)
- Dynamic oral stability secondary to dynamic stability and control in the neck and shoulder girdle
- Planes of movement develop proximal to distal (straight to lateral to diagonal to rotational)
- Motor control involves a circular process of sensory processing/feedback mechanisms
- The auditory, vestibular, proprioceptive, tactile, and visual systems work together for attention, focus, and concentration needed for all motor learning
- First 12 months: Righting and equilibrium reactions help establish normal postural tone, postural control, and reciprocal muscle innervation needed for normal movement
- 3 months: Antigravity extension in head, neck, and thoracic spine as well as flexion in front of upper trunk
- 3-5 months: Head, neck, shoulder girdle, trunk, and pelvic control improve
- 4-6 months: Improved extensor control in hip area, abdominal control, truck rotation, scapular stability, and respiratory control
- 6-12 months: Control of flexion and extension in body
- 8 months: Trunk control
- 7-8 months: Active head, neck, shoulder girdle, rib cage, trunk, and hip activity
- 12 months: Adult-like breathing patterns; mature oral phase swallow emerging
- 24 months: Jaw stability established

First 2 years (Bahr, 2010; Boyd, 2011; Fatemifar et al.,2013; Guilleminault & Huang, in press; Gupta et al., 2007; Handelman & Osborne, 1976; Massignan et al., 2016; Morris, 2003; Morris & Klein, 2000; Must, Phillips, Tybor, Lividini, & Hayes, 2012; Page, 2003; Pillas et al., 2010; Widmar, 1992; Wolf, Anderhuber, & Kuhn, 1993)

Structure

- Facial growth occurs as the cranial base increases in length through endochondral ossification
- The maxilla and mandible move down and forward via muscle function
- The maxilla grows at the mid-palatal suture and the alveolar process accompanying tooth eruption
- Significant cranial, sinus, jaw, lip/cheek, and tongue growth in the first 2 years impacts mouth and airway development
- The mandible grows primarily through endochondral ossification at the temporomandibular condyles
- Primary teeth emerging in a proper sequence, on time, fully formed, with good occlusion between 5 and 30 months is significant for jaw development
- Typical mouth, face, head, and airway development in the first 2 years supports the crucial life processes of eating, drinking, swallowing, speaking, and breathing

Function

- Typical mouth activities (hand-mouth, midline), feeding, eating, drinking, swallowing, speaking, and breathing support typical mouth and airway development (form following function)
  - Generalized mouthing in utero and from birth
  - Discriminative mouthing and teething beginning around 5 to 6 months
  - Mastication beginning around 6 months stimulates jaw growth (phasic bite from birth)
- By age 2, a child should have adult-like feeding skills and should be combining words in speech

Anthony at Birth, 4 months, & 6 months; Parents granted permission for use

First 2 Years: Typical Spoon-Feeding, Cup-Drinking, Finger-Feeding; Hand-Mouth Connection (Bahr, 2010; Morris, 1985, 2003; Morris & Klein, 2000; Stevenson & Allaire, 1991)

SPOON-FEEDING

- 6-7 months: Holds mouth still for spoon; lips move inward slightly when food on them
- 8 months: Upper lip removes food from spoon
- 9-10 months: Holds and/or bangs spoon, imitates stirring
- 12-14 months: Begins to self-feed with spoon
- 15-18 months: Scoops food with a spoon
- 24 months: Has palm up when bringing spoon to mouth

CUP-DRINKING

- 6-8 months: Can take single sips from an open cup held by adult
- 6-12 months: Consecutive sucks from open cup, recessed lid cup, or straw
- 12 months: Holds open or handled cup, and drinks with some spillage
- 15-18 months: May bite on cup rim for stability
- 24 months: Can drink from an open cup without spillage, no longer bites on cup rim

FINGER-FEEDING

- 6-8 months: Picks up food pieces with fist and can hold a soft baby cookie
- 8-9 months: Can pass food from one hand to the other
- 9-12 months: Begins to pick up food with thumb and fingers
- 12-15 months: Can pick up food with thumb and index finger

First 2 Years: Typical Oral Management (Bahr, 2010; Matsuo & Palmer, 2008; Mennella, Reiter, & Daniels, 2016; Morris, 1985, 2003; Morris & Klein, 2000; Stevenson & Allaire, 1991)

6-9 months

- Jaw movements begin matching shape and size of food
- Lips and cheeks help keep food in place
- Tongue moves toward food placed on side gums

9-12 months

- Diagonal rotary chewing increases
- Soft cookie stabilized and broken off
- Lips increasingly active
- Food moved from center of tongue to side

12-15 months

- Can bite through a soft cookie
- Lip corners and cheeks control food placement by 15 months
- Tongue tip elevation to alveolar ridge to initiate swallow (intermittent at first)

15-18 months

- Coordinated diagonal rotary chewing
- Top front teeth remove food from bottom lip as lip moves inward
- Tongue lateralization increasingly sophisticated

18-21 months

- Can bite through a hard cookie with difficulty
- Can chew with lips closed
- Has good control of swallowing

21-24 months

- Can bite through a hard cookie with ease
- Can chew with closed lips using both diagonal rotary and circular rotary chewing (may be teardrop shaped)
- Can easily move tongue tip to place and collect food for chewing and swallowing

First 2 Years: Typical Speech Development (Badin et al., 2002; Bahr, 2010; Coplan, 1987; Donegan, 2002; Dyson, 1988; Grunwell, 1987; Guenther, 1995; Hedrick, Prather, & Tobin, 1984; Ingram, 1981, 1989; Irwin, 1948; Irwin & Chen, 1946; Kent, 1980, 1999; Locke, 1983; Lundberg & Stone, 1999; Oller, 1978, 1980; Oller & Yeni-Komshian, 1980; Ong & Stone, 1998; Owens, 1996; Reidlich & Herzfeld, 1983; Retherford, 2003; Robb & Bleile, 1994; Rossetti, 1990; Stole Gammon, 1985; Stoel-Gammon, & Cooper, 1984; Vulpe, 1977; Wachs, 1976) - much information found in books, tests, and materials

- 1 month: Vowel-like sounds short “a” and long “e”
- 2-3 months: Up to 5 different vowel-like sounds; consonant-like sounds “h, k, and g”
- 3-4 months: Babbling may include “bababa,” “dadada,” and “mamama” with cooing or crying
- 4-6 months: VC and CV syllables developing; most vowel sounds heard
- 6-7 months: Begins to imitate two-syllable babbling; consonants “p, b, m, w, t, d, n, k, g, and y” heard
- 7-9 months: Begins to string vowels together in a sentence-like manner
- 9-12 months: Says first meaningful words
- 12-15 months: Uses 5+ meaningful words; imitates words has not said
- 15-18 months: Says 15-20 meaningful words; names 5-7 objects
- 18-21 months: Two-word stage begins, but primarily speaks in single words
- 21-24 months:
  - Uses 20+ words clearly and appropriately
  - Can say between 50 and 270 words
  - Uses full range of vowel, diphthong, and consonant sounds in speech

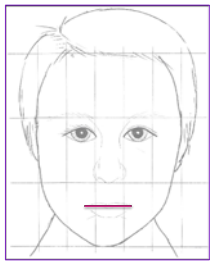
2 to 7 Year Mouth and Airway Development (Bahr, 2010; Boyd, 2011; Guilleminault & Huang, in press; Handelman & Osborne, 1976; Inada et al., 2008; Jahanbin, Rashed, Yazdani, Sharhri, & Kianifar, 2013; Kent, 1999; Lorkiewicz-Muszyńska et al., 2015; Morris, 2003; Morris & Klein, 2000; Page, 2003; Wolf, Anderhuber, & Kuhn, 1993)

- Gradual mouth, face, and head growth
- Structures are shaped by oral resting posture, breathing, eating, drinking, swallowing, and speaking (form following function)
  - Adult-like swallow by 3 years
- Craniofacial dimensions change at differing rates and ages
  - Most extensive growth of the maxillary sinus (birth to 8 years)
  - Significant growth of sphenoid sinus (birth to 5 years)
  - Significant growth of frontal sinus (3-12 years)
  - Growth of ethmoid sinus
- Adult-like vocal tract and adenoids shrink by age 4
- Essentially adult vocal tract by 5 years
- Essentially adult-sized skull and 80% of upper and lower jaw growth by 6 years
- Primary teeth coming out; permanent teeth begin emerging around 6 years in proper sequence, on time, and fully formed (permanent upper and lower first molars and bottom central incisors - 6 to 7 years)
- 80 to 90 % of jaw bone growth occurs by 8 years

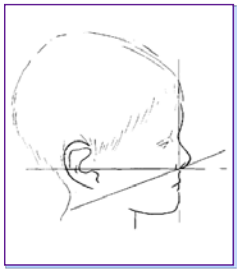
2 to 7 Year Speech Development (Bahr, 2010; Donegan, 2002; Grunwell, 1987; Guenther, 1995; Lipsitt, 1966; Mehrabian, 1970; Owens, 1996; Retherford, 2003; Sander, 1972; Smit, 1986; Van Riper, 1978)

- 2-3 years
  - Speech is clear and understandable
  - Simple 2 and 3 word sentences
  - Says "p, b, m, w, t, d, n, k, g, ng, and h" sounds
  - Says vowels and diphthongs
  - May say "w" for "r"
  - Varies voice loudness
  - May leave out some sounds and/or unstressed syllables
  - May simplify words
- 3-4 years
  - Speech more precise
  - Simple sentences
  - Significant vocabulary increase (900 – 1000 words)
  - Most vowels accurate
  - Says "p, b, m, w, t, d, n, k, g, ng, and h" sounds
  - 50% can say "f, y, r, l, and s" sounds
  - Consonant blends appear and established
- 4 years
  - Increasingly complex sentences
  - Vocabulary increase (1500-1600 words)
  - Says "p, b, m, w, t, d, n, k, g, ng, h, f, and y" sounds
  - 50% can say "r, l, s, z, sh, and ch"
- 5 years
  - Uses adult-like language
  - Says "p, b, m, w, t, d, n, k, g, ng, h, f, v, y, r, l, s, z, sh, and ch"
  - 50% say voiced "th"
- 6 years
  - Says most speech sounds including voiceless "th" and voiced "zh"
- 7 years
  - Speech sound production matures
  - Some have difficulty with "s, z, v, th, and zh"
  - Vocabulary continues to increase

Facial Appearance from Front and Side by Age 6 or Earlier (Allanson, 1997; Bahr, 2010; Boshart, 1999; Downs, 1948; Elgoyhen, Riolo, Graber, Moyers, & McNamara, 1972; Enlow, 1966; Enlow & Moyers, 1971; Enlow, Moyers, Hunter, & McNamara, 1969; Farkas & Deutsch, 1996; Farkas, Katic, & Forrest, 2005; Hirschfeld, Moyers, & Enlow, 1973; Jacobson, 1975: McNamara, 1984; Moyers, Bookstein, & Guire, 1979; Nanda, 1955; Ricketts, 1960; Sassouni, 1969; Scheideman, Bell, Legan, Finn, & Reisch, 1980; Steiner, 1953)



- Eye area width: Approximately 1 eye x 5
- Center eye corners line up with widest part of nose
- Face has appearance of equal thirds
- Top and bottom jaws align
- Straight lip line



- Bridge of nose in line with philtrum and chin
- Angle of nose and philtrum 90-110 degrees
- Top teeth slightly in front of bottom teeth
- Angle from ear lobe to chin point 26 degrees (+/- 4 degrees)

Drawings by Anthony Fotia, property of Diane Bahr

Other Resources on Typical Mouth and Airway Development and Function (Birth to Age 7)

Many **books, tests, materials, and other resources** added to the knowledge presented on typical mouth and airway development and function (Ayers, 1979, Bahr, 2001, 2010; Boehme, 1990; Boshart, 1999; Boyd & Sheldon, 2013; Coplan, 1987; Donegan, 2002; Eisenberg, Murkoff, & Hathaway, 2009; Enlow & Moyers, 1982; Fisher, 1991; Gatto, 2016; Genna, 2017a; Genna & Sandora, 2017; Grunwell, 1987; Hedrick, Prather, & Tobin, 1984; Ingram, 1981, 1989; Kent, 1980, 1999; Locke, 1983; Love & Webb, 1996; Montagu, 1986; Moore, Persaud, & Torchia, 2013; Morris & Klein, 2000; Murkoff, Eisenberg, Hathaway, & Mazel, 2009; Northrup, 2006; Oetter, Richter, & Frick, 1995; Oller, 1980; Owens, 1996; Page, 2003; Page & Mahony, 2015; Perkins & Kent, 1986; Premkumar, 2011; Redstone, 1991; Reidlich, & Herzfeld, 1983; Retherford, 2003; Rossetti, 1990; Sadler, 2012; Samuels & Samuels, 1991; Satter, 2000; Tuchman & Walter, 1994; Upledger, 1996; Upledger & Vredevoogd, 1983; Van der Liden, 1986; Van Riper, 1978; Vulpe, 1977).

Disruptions in Mouth and Airway Development/ Function

UTERO TO AGE 7 YEARS (GENETIC, ENVIRONMENTAL, EPIGENETIC)

Cranio-Facial Abnormality - Cleft Lip and/or Palate (Farronato et al., 2014; Fraser, 1970; Mossey, Little, Munger, Dixon, & Shaw, 2009; Murray, 2002; Parker et al.,2010; Paul & Brandt, 1998; Ranta, 1986; University of Minnesota, nd; Vanderas, 1987; Zucchero et al., 2004)

- Occur between 6th and 12th weeks gestation
- Occur in many syndromes, but may occur in isolation
- In United States approximately 2,650 born with cleft palate, 4,440 born with cleft lip with/without palate; 50 to 80% of clefts isolated (not part of syndrome)
- Higher incidence in males than females; different incidences in races
- Caused by both genetic and environmental factors
- Significant variability of malformations
- Significantly impacts mouth, airway, overall cranio-facial, and dental development
- Problems with intra-oral pressure, velopharyngeal function (hyper- or hypo-nasality), breathing, feeding, eating, drinking, swallowing, speaking (e.g., "f, v, th, s, z, sh, zh, ch, j, t, d, p, b, k, g"), voicing, hearing, and social interaction

Tethered Oral Tissues –TOTs (References in next slide)

Tongue, lip, and buccal ties reportedly occur in utero during early mouth development (2 to 8 weeks gestation)

Tongue tie/ankyloglossia: A congenital condition limiting tongue mobility secondary to atypical lingual frenum, may also limit mandibular growth and impact maxillary growth

- Believed to result from remaining (left-over) stretch-resistant tissues (type 1 collagen) which normally die during gestation in a process called apoptosis or programmed cell death.
- Prevalence: 3-12% of newborns
- Inheritance passed in an autosomal dominant fashion
- Found in more males than females
- Breastfeeding difficulties with latch, milk transfer, mother's nipple pain, poor weight gain, and early weaning
- Bolus placement and collection concerns, inhibition of the normal swallow, oral hygiene difficulties, and speech problems

Tethered Oral Tissue References

Acevedo et al., 2010; Ballard, Auer, & Khoury, 2002; Buryk, Bloom, Shope, 2011; Cockley & Lehman, 2015; Coryllos, Genna, & Salloum, 2004; Defabianis, 2000; Dollberg, Botzer, Grunis, & Mimouni, 2006; Emond et al.,2014; Forlenza, Black, McNamara, & Sullivan, 2010; Garbin et al., 2013; Gatto, 2016; Geddes, Kent, Mitoulas, & Hartmann, 2008; Geddes et al., 2008; Genna, 2017b; Griffiths, 2004; Guilleminault, Huseni, & Lo, 2016; Haham, Marom, Mangel, Botzer, & Dollberg, 2014; Han, Kim, Choi, Lim, & Han, 2012; Hazelbaker, 2010; Hogan, Westcott, & Griffiths, 2005; Hong et al., 2010; Jang et al.,2011; Klockars & Pitkäranta, 2009a, 2009b; Knox, 2010; Kotlow, 1999, 2004, 2016; Kupietzky & Botzer, 2005; Livingstone, Willis, Abdel-Wareth, Thiessen, & Lockitch, 2000; Martinelli, Marchesan, & Berretin-Felix, 2012, 2014; Martinelli, Marchesan, Gusmão, Rodrigues, & Berretin-Felix, 2014; Messner & Lalakea, 2002; Messner, Lalakea, Aby, Macmahon, & Bair, 2000; Miranda & Milroy, 2010; Northcutt, 2009; Pola, Garcia, Martín, Gallas, & Lestón, 2002; Pransky, Lago, & Hong, 2015; Queiroz, 2004; Reddy, Marudhappan, Devi, & Narang, 2014; Ricke, Baker, Madlon-Kay, & DeFor, 2005; Todd, 2014; Westcott, Hogan, & Griffiths, 2006; Yoon et al., 2017

Limited Sucking/Buccal Fat Pads (Bagdade & Hirsch, 1966; Bahr, 2010; Einarsson-Backes, Deitz, Price, Glass, & Hays, 1994; Geddes, Kent, Mitoulas, & Hartmann, 2008; Genna & Sandora, 2017; Hill, 2005; Hill, Kurkowski & Garcia, 2000; Jackson, 1999; Morris, 2003; Morris & Klein, 2000; Patil, Singh, & Subba Reddy, 2003; Ponrartana et al., 2014; Racz, Maros, & Seres-Sturm, 1989; Ramsay & Hartman, 2005; Rudolph & Link, 2002; Tostevin & Ellis, 1995)

- Sucking/Buccal Fat Pads develop toward the end of gestation when the other fat is developing on the baby's body
- Provide lateral support and stability during feeding/sucking by helping to keep the tongue grooved and in midline
- Keep the mouth from collapsing during sucking, and help the baby attain adequate intra-oral pressure for feeding
- Seem to thin between 4 and 6 months of age when the baby is getting ready for more mature feeding processes
- Undeveloped in premature infants (do not develop after birth)
- Clinically, some near-term and full-term babies have limited sucking/buccal fat pads
- Carefully applied cheek support can help babies compensate for limited sucking/buccal fat pads
- Research is needed because some babies are being treated for tongue tie (only) when they also have under-developed sucking/buccal fat pads and apparent jaw concerns

Disruptions in Movement and Positioning (Chizawsky & Scott-Findlay, 2005; Dudek-Shriber & Zelazny, 2007; Graham, 2006; Graham, Gomez, et al., 2005; Graham, Kreutzman, et al., 2005; Hollier, Kim, Grayson, & McCarthy, 2000; Hutchison, Hutchison, Thompson, & Mitchell, 2004; Koren, Reece, Kahn-D'angelo, & Medeiros, 2010; Laughlin, Luerssen, Dias, et al., 2011; Miller, Johnson, Duggan, & Behm, 2011; Persing, James, Swanson, Kattwinkel, et al., 2003; Solow, & Sandham, 2002; Wen, Baur, Simpson, Rissel, & Flood, 2011; Zachry & Kitzmann, 2011)

- What may be occurring with *excessive* swaddling, use of containers (car seats, baby seats, swings, etc.), and time on the back?
- How do babies develop adequate postural control, gross motor skills, and fine motor skills (mouth, eye, hand movement)?
- Why may we be seeing more plagiocephaly and torticollis, as well as late developing feeding, speech, vision, and writing skills?

- Could It Be Babies Are Not:
  - Weight bearing and moving appropriately to develop postural control and normal movement patterns throughout the body (proximal to distal, cephalo-caudal)
  - Experiencing an appropriate variety of positioning and movement experiences throughout the body (e.g., tummy time, side-lying, etc.)

Mouth Breathing

(Abreu, Rocha, Lamounier, & Guerra, 2008a, 2008b; Behlfelt, Linder-Aronson, McWilliam, Neander, & Laage-Hellman, 1989; Bresolin, Shapiro, Shapiro, Chapko, & Dassel, 1983; Cheng et al. 1988; Faria, Ruellas, Matsumoto, Anselmo-Lima, & Pereira, 2002; Gatto, 2016; Gelb & Hindin, 2016; Guilleminault & Huang, in press; Harari, Redlich, Miri, Hamud, & Gross, 2010; Lee et al., 2007; Lee, Guilleminault, Chiu, & Sullivan, 2015; Lima, Baraúna, Sologurem, Canto, & Gastaldi, 2004; Lundberg & Weitzberg, 1999; Marangu, Jowi, Aswani, Wambani, & Nduati, 2014; Martha et al., 2013; Mattar, Anselmo-Lima, Valera, & Matsumoto, 2004; Miller, Vargervik, & Chierici, 1984; Motta, Bachiega, Guedes, Laranja, & Bussadori, 2011; Neiva, Kirkwood, & Godinho, 2009; Padzys, Martrett, Tankosic, Thornton & Trabalon, 2011; Schlenker, Jennings, Jeiroudi, & Caruso, 2000; Shetty & Munshi, 1998; Souki et al., 2009; Vargervik, Miller, Chierici, Harvold, & Tomer, 1984; Vlahandonis, Walter, & Horne, 2013)

- Low resting tongue positions and high, narrow palates
- Long, narrow faces
- Poorly developed oral and airway structures
- Upper respiratory illnesses
- Inefficient oral phase swallowing patterns
- Airway obstructions
  - Enlarged tonsils and adenoids
  - Enlarged turbinates and swelling
- Problems with tooth eruption and decay
- Dental malocclusions
- Halitosis
- Postural concerns
- Sleep disordered breathing
- Cardiac problems
- Pulmonary hypertension

Sleep Disordered Breathing (References in next slide)

- Sleep disordered breathing (SDB) in children
  - Obstructive sleep apnea (OSA): Partial or full upper airway collapse
  - Central sleep apnea (CSA): Central nervous system disorder with partial or fully blocked airways
  - Mixed sleep apnea: Combination of OSA and CSA
  - Prevalence in children: Wide variations from 0.7% to 13%
- Symptoms
  - Snoring
  - Mouth breathing and nasal disuse
  - Apnea (stopping breathing)
  - Daytime sleepiness
  - Poor cranio-facial growth with low oro-facial muscle tone
  - Small upper airways
  - Oro-facial myofunctional disorders
  - Bed-wetting
  - Morning headache
- Risk factors for SDB
  - Mothers who smoked
  - Children who were preterm, low birthweight, had a history of wheezing, or were not breastfed
  - Childhood obesity
  - Families of lower socio-economic status
- Potential Impact
  - Growth problems (e.g., failure to thrive)
  - Heart and breathing problems
  - Learning problems
  - Behavioral concerns
  - Irritability
  - Attention deficit disorder
  - Attention deficit hyperactivity disorder

Sleep Disordered Breathing References

Arens et al., 2003; Bhattacharjee et al., 2010; Bonuck, et al., 2011; Bonuck, Freeman, Chervin, & Xu, 2012; Camacho et al., 2015; Cheng et al, 1988; Chuang, Lian, Hervy-Auboiron, Guilleminault, & Huang, 2017; Fitzpatrick et al., 2003; Gaultier & Guilleminault, 2001; Gelb & Hindin, 2016; Guilleminault, Abad, Chiu, Peters, & Quo, 2016; Guilleminault & Akhtar, 2015; Guilleminault & Huang, in press; Guilleminault, Huang, Glamann, Li, & Chan, 2007; Guilleminault, Huang, et al., 2013; Guilleminault, Huseni, & Lo, 2016; Guilleminault & Pelayo, 1998; Guilleminault, Primeau, et al., 2013; Guilleminault & Sullivan, 2014; Handelman & Osborne, 1976; Huang & Guilleminault, 2013; Huang et al., 2016; Huang, Guilleminault, Lee, Lin, & Hwang, 2014; Huang, Paiva, Hsu, Kuo, & Guilleminault, 2014; Huang, Quo, Berkowski, & Guilleminault, 2015; Jamieson, Guilleminault, Partinen, & Quera-Salva, 1986; Lee et al., 2007; Lee, Guilleminault, Chiu, & Sullivan, 2015; Mankarious & Goudy, 2010; Marcus, 2001; Marcus, Katz, et al., 2005; Marcus, McColley, et al., 1994; Miller, Vargervik, & Chierici, 1984; Moeller, Paskay, & Gelb, 2014; Montgomery-Downs & Gozal, 2006; Pirilä-Parkkinen et al., 2008; Schlenker, Jennings, Jeiroudi, & Caruso, 2000; Songu, Adibelli, Tuncyurek, Adibelli, 2010; Sullivan, Li, & Guilleminault, 2008; Vargervik, Miller, Chierici, Harvold, & Tomer, 1984; Villa et al., 2015; Wasaki & Yamasaki, 2014; Wolf, Anderhuber, & Kuhn, 1993

Impact of Missing Permanent Teeth on Face, Jaw, and Airway Development

(Ben-Bassat & Brin, 2003; Guilleminault, Abad, Chiu, Peters, & Quo, 2016; Guilleminault & Huang, in press; Lisson, & Scholtes, 2005; Shimizu & Maeda, 2009; Tavajohi-Kermani, Kapur, & Sciote, 2002)

- Dento-alveolar growth until approximately 15 years widens and lengthens the mouth
- Congenital absence of permanent teeth roots (oligodontia) can be seen on early x-rays
- Oligodontia and concurrent obstructive sleep apnea (OSA) seem to run in families (a minimum of 70 genes impact tooth development)
- As few as 2 missing permanent teeth in children with oligodontia or tooth extractions
  - Can impact jaw growth resulting in long, narrow faces; high, narrow palatal vaults; underdeveloped lower jaws; and a jaw slide to the right
  - Tooth development and jaw development go hand-in-hand
  - Changes in the jaw impact the upper airway and can lead to OSA which seems to worsen with age
  - The maxilla and mandible are the bony structures supporting the upper airway muscles

Disrupted Oral Development - Mouthing, Feeding, and Speech (Alcock, & Krawczyk, 2010; Bahr, 2001, 2003, 2010; Bahr & Johanson, 2013; Boyd, 2011; Gatto, 2016; Grace, Oddy, Bulsara, & Hands, 2017; Guilleminault, Huseni, & Lo, 2016; Hogan, Westcott, & Griffiths, 2005; Kent, 2015; Manno, Fox, Eicher, & Kerwin, 2005; Matsuo & Palmer, 2008; Melsen, Attina, Santuari, & Attina, 1987; Messner, Lalakea, Aby, Macmahon, & Bair, 2000; Morris & Klein, 2000; Oliveira, Paiva, Martins, Torres, & Pordeus, 2011; Oliveira, Pordeus, Torres, Martins, & Paiva, 2010; Pola, Garcia, Martín, Gallas, & Lestón, 2002; Queiroz, 2004; Todd, 2014; Westcott, Hogan, & Griffiths, 2006)

Mouthing Issues

- Generalized mouthing continues in lieu of discriminative mouthing; child does little or skips discriminative mouthing
- Child does not bite and chew on appropriate foods or items to assist with teething and jaw development - Lip and tongue development (muscular structures) seem to follow jaw development (skeletal structure on which soft tissues/muscles attach)
- Excessive sucking or other detrimental oral habits and malocclusion

Feeding Issues

- Oral sensory and/or motor problems (e.g., late developing postural control and oral fine motor functions, tongue tie, atypical oral phase swallow, oral sensitivity/awareness issues, selective eating, detrimental oral feeding habits)
- Foods and feeding skills not introduced on time (e.g., taking appropriate bites of food, lateralizing foods with the tongue, chewing at the back molar areas; problems with placement and collection of the bolus, finger feeding, utensil use, etc.)
- Behavioral issues (behavior is communication)

Speech Issues

- Late developing speech (fine motor function) along with late developing postural control and gross motor skills
- Oral sensory and/or motor problems (e.g., oral sensitivity/awareness issues, immature/unrefined oral sensory-motor patterns, tongue tie, atypical oral phase swallow connected with specific speech problems, etc.)
- Detrimental oral habits inhibiting appropriate vocal and speech development (e.g., ongoing/long-term pacifier use, thumb/finger sucking, etc.)

Detrimental Oral Habits (Adair, 2003; Barros de Arruda Telles, Ferreira, Magalhaes, & Scavone-Junior, 2009; Bishara, Warren, Broffitt, & Levy, 2006; Dimberg, Bondemark, Söderfeldt, & Lennartsson, 2010; Dimberg, Lennartsson, Söderfeldt, & Bondemark, 2011; Farsi & Salama, 1997; Ferrante & Ferrante, 2015; Garattini, Crozzoli, & Valsasina, 1990; Heimer, Tornisiello Katz, & Rosenblatt, 2008; Larsson, 1994; Majorana, Bardellini, Amadori, Conti, & Polimeni, 2015; Melsen, Attina, Santuari, & Attina, 1987; Neto, Oliveira, Barbosa, Zandonade, & Oliveira, 2012; Oliveira, Paiva, Martins, Torres, & Pordeus, 2011; Oliveira, Pordeus, Torres, Martins, & Paiva, 2010; Poyak, 2006; Scoppa, Ferrante, De Cicco, Ferrante, & Ciaravolo, 2009; Shotts, McDaniel, & Neeley, 2008; Silveira, Prade, Ruedell, Haeffner, & Weinmann, 2013; Warren & Bishara, 2002; Warren, Levy, Nowak, & Tang, 2000; Warren et al., 2005; Zardetto, Rodrigues, & Stefani, 2002)

- Long-term or excessive
  - Bottle use or bottle-like use (e.g., spouted cups, pouch foods)
  - Pacifier use
  - Thumb or digit sucking
  - Generalized mouthing
- Results
  - High, narrow palates and long, narrow faces
  - Upper airway issues
  - Poor jaw growth
  - Atypical oral phase swallow
  - Dental malocclusions
  - Speech problems (often persistent sibilant, “r,” and “l” disorders)

Epigenetics

(Boyd, 2011; 2012; Gibbons, 2012; Neto, Oliveira, Barbosa, Zandonade, & Oliveira, 2012; Silveira, Prade, Ruedell, Haeffner, & Weinmann, 2013)

- Genetic changes seem to be on the rise in oral, facial, and airway structures
- Could this be related to practices in industrialized societies such as:
  - Bottle feeding and other unnatural feeding practices (e.g., pouch foods, spouted cups, etc.)?
  - Availability of soft, convenience foods instead of foods requiring adequate mastication?
  - Excessive pacifier use and other detrimental oral habits?
- Are other changes such as an apparent increase in tongue ties, retruded lower jaws, decrease in sucking pad development, etc. related to genetic changes in the species?
- Could awareness, assessment, and treatment of disruptions in mouth and airway development and function help to reverse this process?

Other Resources on Disruptions in Mouth and Airway Development and Function (Birth to Age 7)

Some **books and other resources** added to the knowledge presented on disruptions in mouth and airway development and function (Bahr, 2001, 2010; Boyd & Sheldon, 2013; Genna, 2017a, 2017b; Gatto, 2016; Gelb & Hindin, 2016; Hazelbaker, 2010; Kotlow, 2016; Morris & Klein, 2000)

Assessment of Disruptions in Mouth and Airway Development/Function

BIRTH TO AGE 7 YEARS

Assessment of the Orofacial Complex

(Arvedson, 2008; Coulthard, Harris, & Emmett, 2009; Pecoraro, Inui, Chen, Plorde, & Heller, 1979)

Case History that includes information regarding:

- Birth and developmental histories
- Medical history
- Histories of injuries, illnesses, surgical intervention, and allergies (food and seasonal), snoring, and disruptions in airway patency
- Dental history including tooth eruption, carries (oral hygiene), and changes in the dentition
- Feeding history including longevity of breast- and bottle-feeding; introduction of solid foods; types of cups, spoons, and utensils; types of foods that are typical in the child's diet; and digestive issues (e.g., gastroesophageal reflux)
- Noxious habit usage (e.g., thumb sucking)
- Breathing history including breathing postures during day and at night, sleep disorder breathing (SDB)
- Previous interventions (Occupational, physical, and/or speech-language therapy)
- Milestones of speech, hearing, language, and development

Assessment of Static Structures and Functional Abilities of the Orofacial Complex (References in next slide)

Areas of static assessment

- facial shape
- facial symmetry
- patency of the airway
- philtrum length and angle
- labial structure
- maxillary, buccal, and mandibular labial frena
- dentition
- lingual appearance
- lingual frenulum
- oropharyngeal isthmus
- tonsil size
- palatal shape/size

Areas of functional assessment

- breathing/respiration
- movement abilities of the jaw, tongue, and lips and their role in bolus preparation, formation, and transit
- cranial nerve integrity
- sensory processing in body and intraorally
- articulation of the dentition
- parafunctional habits (abnormal chewing or sucking)
- swallow function
- speech
- readiness for intervention

Assessment of Static Structures and Functional Abilities of the Orofacial Complex - References

(Allanson, 1997; Audag, Goubau, Toussaint, & Reychler, 2017; Bahr, 2003; Bosma, 1963b; Bresolin, Shapiro, Shapiro, Chapko, & Dassel, 1983; Cichero, 2017; Da Costa, van den Engel-Hoek & Bos, 2008; Enlow, 1966; Enlow & Moyers, 1971; Enlow, Moyers, Hunter, & McNamara, 1969; Gewolb & Vice, 2006; Grace, Oddy, Bulsara, & Hands, 2017; Green, Moore, Higashikawa, & Steeve, 2000; Green, Moore, Reilly, 2002; Handelman & Osborne, 1976; Hiiemae & Palmer, 2003; Hiraki, Yamada, Kurose, Ofusa, Sugiyama, & Ishida, 2017; Martinelli, Marchesan, & Berretin-Felix, 2014)

Assessment of Breathing and Respiration

(Camacho, et al., 2015; Chervine, Hedger, Dillon, & Pituch, 2000; Gaultier & Guilleminault, 2001; Gola, Cheynet, Guyot, Sauvant, & Richard, 2000; Guilleminault & Sullivan, 2014; Guilleminault & Achtar, 2015; Guilleminault & Huang, in press; Owens, 2005)

Simple sleep questionnaires

1. BEARS (**B**edtime problems, **E**xcessive daytime sleepiness, **A**wakenings during the night, **R**egularity and duration of sleep, **S**noring) (Owens, 2005)
2. Pediatric Sleep Questionnaire (Chervine, 2000)

Assessment of Postures (References in next slide)

- Body Postures in sitting, standing, and walking
- Breathing mechanism and the impact on oral postures
- Phonatory function and impact
- Resonance function and impact

Assessment of the Postures - References

(Arens, et al., 2003; Bahr, 2003; Ballard, Auer, & Khoury, 2002; Barcelo, Mirapeix, Buges, Cobos, & Domingo, 2011; Bosma, Hepburn, Josell, & Baker, 1990; Chervin, Hedger, Dillon, & Pituch, 2000; Chizawsky & Scott-Findlay, 2005; Connaghan, Moore, & Higashakawa, 2004; Da Costa, van den Engel-Hoek, & Bos, 2008; Faria, Ruellas, Matsumotor, Anselmo-Lima, & Pereira, 2002; Fitzpatrick, McLean, Urton, Tan, O'donnell, & Driver, 2003; Folha, Valera, & de Felicio, 2015; Friedman, Hamilton, & Samuelson, 2012; Friedman, Hamilton, Samuelson, Lundren, & Pott, 2013; Gewolb, & Vice, 2006; Junqueira, Marcheson, de Oliverira, Ciccone, Haddad, & Rizzo, 2010; Leder, Suiter, Murray, & Rademaker, 2013; Lundberg, & Stone, 1999; Lundberg, & Weitzberg, 1999; Mankarious & Goudy, 2010; Pacheco, Fiorott, Finck, & de Araújo, 2015; Rodrigues, Dibbern, Goulart, & Palma, 2010; Rossi, Rossi, Rossi, Yamashita, & Pignatari, 2015; Songu, Adibelli, Tuncyurek, & Adibelli, 2010; Takemoto, 2001; Valera, Trawitzki, & Anselmo-Lima, 2006; Wen, Baur, Simpson, Rissel, & Flood, 2011)

Assessment of the External Features of the Orofacial Complex (References in next slide)

- Head and facial shape
- Profile
- Symmetry – midline
- Alignments of the eyes, nose, and ears
- Direction of jaw growth and alignment

Assessment of the External Features of the Orofacial Complex - References

(Allanson, 1997; Bahr, 2003; Ballard, Auer, & Khoury, 2002; Castelo, Bonjardim, Pereira, & Gavião, 2008; Castelo, Gavião, Pereira, & Bonjardim, 2010; Castelo, Pereira, Andrade, Marquezin, & Gavião , 2010; Cattoni & Fernandes, 2004; Farkas, Katic, & Forrest, 2005; Fayoux, Marciniak, Devisme, & Storme, 2008; de Felicio,& Ferriera, 2008; de Felicio, Folha, Ferreira, & Medeiros, 2010; de Felicio, Folha, Gaido, Dantas & Azevedo-Marques, 2014; Folha, Valera & de Felicio, 2015; Genaro, Berretin-Felix, Rehder & Marchesan, 2009; Graziani, Fukushiro & Genaro, 2015; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Macedo & Bianchini, 2014; Mankarious & Goudy, 2010; Marchesan, Berretin-Felix, & Genaro, 2012; Meenakshi & Jagannathan, 2014; Pacheco, Fiorott, Finck, & de Araújo, 2015; Paskay, 2006; Paskay, 2012; Ratnovsky, Carmeli, Elad, Zaretsky, Dollberg, & Mandel, 2013; Stål, Marklund, Thornell, De Paul, & Eriksson, 2003; Valera, Trawitzki, & Anselmo-Lima, 2006)

Assessment of the Cranial Nerves (CN)

(Allanson, 1997; Bahr, 2003; Chizawsky, 2005; Da Costa, van den Engel-Hoek & Bos, 2008; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo; Rogers & Arvedson, 2005)

- Identify the functional integrity of the cranial nerves
- Assess the nerves involved in the oropharyngeal complex and swallowing – CN V, VII, IX, X, XI, XII

Assessment of the Oral Cavity

(Marchesan, 2012; Martinelli, Marchesan, & Berretin-Felix, 2012; Olivi, Signare, Olivi & Genovese, 2012; Kumar, et al., 2014; Sjogreen, Lohmander, & Kiliarids, 2011; Hiraki, Yamada, Kurose, Ofusa, Sugiyama, & Ishida, 2017; Manipon, 2016; Leder, Suiter, Murray, & Rademaker, 2013; Walsh, Links, Boss, & Tunkel, 2017)

- Oral Mechanism Examination (jaw, lips, tongue, teeth, hard and soft palates)
- Mallampati Scores
- Brodsky's Tonsil Assessment
- Lingual Frenulum Protocols
- Lip Mobility and Force
- Dental Eruption and Exfoliation Patterns

Assessment of Jaw Structure and Function (References in next slide)

STRUCTURE at rest

- Bone structure
  - Mandible
  - Angle of the Ramus
  - Palpation of the Condyle
- Muscles of the Jaw
  - Masseter
  - Temporalis
  - Medial Pterygoid
  - Lateral Pterygoid
  - Anterior Belly of the Digastric

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FUNCTION in chewing, bolus collection and transfer, and speaking

- Elevation
- Depression
- Protrusion
- Lateralization
- Symmetry in physiology
- Chewing development from munch chew to circular, rotary chew pattern
- Speech development beginning with vowels and 5 positions of the vowel quadrilateral

Assessment of the Jaw - References

(Allanson, 1997; Bahr, 2003; Ballard, Auer & Khoury, 2002; Boyd, 2011; Castelo, Bonjardim, Pereira, & Gavião, 2008; Castelo, Pereira, Andrade, Marquezin, & Gavião, 2010; Cerezo, Lobato, Pinkos, & LeLeiko, 2011; Cichero, 2017; Coulthard, Harris, & Emmett, 2009; Da Costa, van den Engel-Hoek & Bos, 2008; Faria, Ruellas, Matsumoto, Anselmo-Lima, & Pereira, 2002; de Felicio & Ferreira, 2008; Fitzpatrick, McLean, Urton, Tan, O'donnell, & Driver, 2003; Gewolb & Vice, 2006; Green, Moore, Higashikawa, & Steeve, 2000; Green, Moore, & Reilly, 2002; Iguchi, Magara, Nakamura, Tsujimura, Ito, & Inoue, 2015; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Mankarious & Goudy, 2010; Pacheco, Fiorott, Finck, & de Araújo, 2015; Pizolato, Fernandes, & Gavião, 2011; Rogers & Arvedson, 2005)

Assessment the Labial Musculature (References in next slide)

Muscles of the Lips: Orbicularis Oris, Levator Anguli Oris, Levator Labii Superiois, Zygomaticus Major and Minor, Buccinator, Risorius, Triangularis, Mentalis, and Platysma

STRUCTURE at rest

- Vermillion health
- Symmetry from left to right
- Symmetry from top to bottom
- Resting posture of the lips
- Maxillary and mandibular frenum

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FUNCTION in feeding and speech

- Retraction
- Elevation
- Protrusion
- Depression
- Closure
- Review of functional movement in liquid and solid consumption
- Movement in speech production

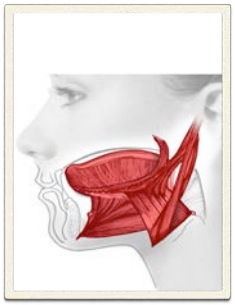
Assessment of the Lips - References

(Bahr, 2003; Ballard, Auer, & Khoury, 2002; Da Costa, van den Engel-Hoek, & Box, 2008; de Felicio & Ferreira, 2008; Gewolb & Vice, 2006; Green, Moore, Higashikawa, & Steeve, 2000; Green, Moore, & Reilly, 2002; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Kotlow, 2013; Smithpeter & Covell, 2010)

Assessment of the Lingual Musculature
(References in next slide)

Intrinsic muscles – Superior Longitudinal, Inferior Longitudinal, Transverse, and Vertical
Extrinsic muscles – Genioglossus, Hyoglossus, Palatoglossus, and Styloglossus

STRUCTURE at rest
- Shape
- Size
- Lingual frenum
- Location of lingual resting posture



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FUNCTION in swallowing and speech
- Elevation
- Depression
- Lateralization
- Narrowing
- Cupping
- Dissociation
- Suctioning
- Bolus collection and transfer
- Articulation
- Symmetry of movement

Assessment of the Tongue - References

(Amir, James, & Donath, 2006; Arvedson, 2008; Audag, Goubau, Toussaint, & Reychler, 2017; Bahr, 2003; Ballard, Auer, & Khoury, 2002; Bosma, Hepburn, Josell, & Baker, 1990; Cattoni & Fernandes, 2004; Cerezo, Lobato, Pinkos, & LeLeiko, 2011; de Felicio & Ferreira, 2008; de Felício, Folha, Ferreira, & Medeiros, 2010; de Felício, Folha, Ferreira, Paskay, & Sforza, 2015; de Felicio, Folha, Gaido, Dantas, & Azevedo-Marques, 2014; de Felício, Medeiros, de Oliveira, & Melchior, 2012; Fernando, 1998; Folha, Valera, & de Felicio, 2015; Friedman, Hamilton, & Samuelson, 2012; Friedman, Hamilton, Samuelson, Lundgren, & Pott, 2013; Geddes, Kent, Mitoulas, & Hartmann, 2008; Geddes, Langton, Gollow, Jacobs, Hartmann, & Simmer, 2008; Genaro, Berretin-Felix, Rehder, & Marchesan, 2009; Gewolb & Vice, 2006; Ghahaeri, Cole, Fausel, Choup, & Mace, 2017; Grace, Oddy, Bulsara, & Hands, 2017; Graziani, Fukushiro, & Genaro, 2015; Green, Moore, Higashikawa, & Steeve, 2000; Green, Moore, & Reilly, 2002; Hiiemae & Palmer, 2003; Hong, Lago, Seargeant, Pellman, Magit, & Pransky, 2010; Hori, et. al., 2013; Ingram, Johnson, Copeland, Churchill, Taylor, & Emond, 2015; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Knox, 2010; Kotlow, 1999; Kupietzky & Botzer, 2005; Macedo & Bianchini, 2014; Madlon-Kay, Ricke, Baker, & DeFor, 2008; Manipon, 2016; Marchesan, 2004; Marchesan, 2012; Marchesan, Berretin-Felix, & Genaro, 2012; Martinelli, Marchesan, & Berretin-Felix, 2012; Meenakshi & Jagannathan, 2014; Olivi, Signore, Olivi, & Genovese, 2012; Paskay, 2006; Paskay, 2012; Stål, Marklund, Thornell, De Paul, & Eriksson, 2003; Tamura, Matsushita, Shinoda, & Yoshida, 1998; Um, Hong, & Jeong, 2017; Wanderley, et al., 2013; Wen, Baur, Simpson, Rissel, & Flood, 2011; Yoon, et al., 2017)

Assess Structure and Function – Symmetry, oral/nasal resonance, fissure or abnormalities of the palatine suture, bifid uvula
(References in next slide)

STRUCTURE at rest
- Shape
- Size or length
- Symmetry

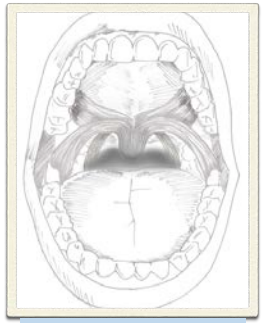


Image owned by Kristie Gatto

FUNCTION during swallowing and in speech
- Resonance
- Phonemic-specific productions

Assessment of Hard and Soft Palates - References

(Allanson, 1997; Arens, et al., 2003; Arvedson, 2008; Audag, Goubau, Toussaint, & Reychler, 2017; Barcelo, Mirapeix, Buges, Cobos, & Domingo, 2011; Bahr, 2003; Bosma, Hepburn, Josell, & Baker, 1990; Cattoni & Fernandes, 2004; Cerezo, Lobato, Pinkos, LeLeiko, & Cichero, 2017; Coulthard, Harris, & Emmett, 2009; Da Costa, Van Den Engel-Hoek, & Bos, 2008; Faria, Ruellas, Matsumoto, Anselmo-Lima, & Pereira, 2002; Fayoux, Marciniak, Devisme, & Storme, 2008; de Felicio & Ferreira, 2008; de Felício, Folha, Ferreira, & Medeiros, 2010; de Felício, Folha, Ferreira, Paskay, & Sforza, 2015; de Felicio, Folha, Gaido, Dantas, & Azevedo-Marques, 2014; de Felício, Medeiros, & de Oliveira Melchior, 2012; Folha, Valera, & de Felicio, 2015; Friedman, Hamilton, & Samuelson, 2012; Friedman, Hamilton, Samuelson, Lundgren, & Pott, 2013; Geddes, Langton, Gollow, Jacobs, Hartmann, & Simmer, 2008; Genaro, Berretin-Felix, Rehder, & Marchesan, 2009; Gewolb & Vice, 2006; Grace, Oddy, Bulsara, & Hands, 2017; Graziani, Fukushiro, & Genaro, 2015; Hori, et al., 2013; Jacobs, Dickinson, Hart, Doherty, & Faulkner, 2007; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Knox, 2010; Kumar, et al., 2014; Macedo & Bianchini, 2014; Manipon, 2016; Marchesan, Berretin-Felix, & Genaro, 2012; Pacheco, Fiorott, Finck, & de Araújo, 2015; Paskay, 2006; Paskay, 2012)

Assessment of Swallowing Physiology
(References in next slide)

- Breast and/or bottle feeding
- Salivary control
- Aberrant facial movements
- Drinking and eating by various mediums of transit (cup, straw, spoon, bottle)
- Variances with viscosities
- Overall functional bolus collection, manipulation, and transit for a safe swallow

Assessment of Swallowing - References

(Amir, James, & Donath, 2006; Arvedson, 2008; Audag, Goubau, Toussaint, & Reychler, 2017; Bahr, 2003; Ballard, Auer, & Khoury, 2002; Bosma, Hepburn, Josell, & Baker, 1990; Castelo, Bonjardim, Pereira, & Gavião, 2008; Castelo, Gavião, Pereira, Bonjardim, 2010; Castelo, Pereira, Andrade, Marquezin, & Gaviao, 2010; Cerezo, Lobato, Pinkos,& LeLeiko, 2011; Cichero, 2017; Coulthard, Harris, & Emmett, 2009; Da Costa, Van Den Engel-Hoek, &Bos, 2008; de Felicio & Ferreira, 2008; de Felício, Folha, Ferreira, & Medeiros, 2010; de Felício, Folha, Ferreira, Paskay, & Sforza, 2015; de Felicio, Folha, Gaido, Dantas, & Azevedo-Marques, 2014; de Felício, Medeiros, de Oliveira Melchior, 2012; Fernando, 1998; Folha, Valera, de Felicio, 2015; Geddes, Langton, Gollow, Jacobs, Hartmann, & Simmer, 2008; Genaro, Berretin-Felix, Rehder, & Marchesan, 2009; Gewolb & Vice, 2006; Ghahaeri, Cole, Fausel, Choup, & Mace, 2017; Grace, Oddy, Bulsara, & Hands, 2017; Graziani, Fukushiro, & Genaro, 2015; Hiiemae & Palmer, 2003; Hill, et al., 2015; Hori, et al., 2013; Iguchi, Magara, Nakamura, Tsujimura, Ito, & Inoue, 2015; Jacobs, Dickinson, Hart, Doherty, & Faulkner, 2007; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Knox, 2010; Kotlow, 1999; Kotlow, 2013; Lau & Kusnierczyk, 2001; Macedo & Bianchini, 2014; Manipon, 2016; Marchesan, Berretin-Felix, & Genaro, 2012; Paskay, 2006; Paskay, 2012; Ratnovsky, Carmeli, Elad, Zaretsky, Dollberg, & Mondel, 2013; Reghav, et. al., 2010; Rogers & Arvedson, 2005; Todd, 2014; Vlahandonis, Walter, & Horne, 2013)

Assessment of Swallowing Function (da Costa, van den Engel-Hoe & Bos, 2008; de Costa, Remijn, Weenen, Vereijken, & van der Schans, 2017; Audag, Goubau, Toussaint, & Reychler, 2017; Gosa, Carden, Jacks, Threadgill, & Sidlovsky, 2017; Rendon-Macias, Villasis-Keever, & del Carmen Martinez-Garcia, 2016; Vivers, Kritzinger, Vinck, & Graham, 2017)

Da Costa, et al. discussed the current need for the development of reliable, user-friendly, and non-invasive diagnostic tools to study sucking and swallowing

Rendon-Macias, et al. determined the reliability and validity of the clinical nutritional sucking scale with newborn infants. This scale establishes the different patterns of sucking abnormalities related to the history of neurological abnormalities, hemodynamic alteration, and immaturity

Audaq, et al. concluded that no superior validated tools for screening or evaluation of dysphagia have been identified; nor has a widely accepted protocol

Vivers, et al. concluded that the Neonatal Feeding Assessment Scale was promising and a study for further validation was needed.

Assessment of the Parafunctional Habits
(Adair, 2003; Bahr, 2003; Bahr & Rosenfeld-Johnson, 2010; de Felicio & Ferreira, 2008; Farsi & Salama, 1997; Junqueira, Marchesan, de Oliveira, Ciccone, Haddad, & Rizzo, 2010; Lau & Kusnierczyk, 2001; Poyak, 2006; Rendon-Macias, Villasis-Keever, & del Carmen Martinez-Garcia, 2016; Zardetto, Rodrigues, & Stefani, 2002; Shotts, McDaniel, & Neeley, 2008)

- Noxious habits can lead to a variety of changes in the dental structure, muscle building and acuity, sound development, and psychological development of the child.
- When a noxious habit is continuous, changes in the normal developmental patterns of the associated areas are observed consistently.
- These changes affect the dentition, the palatal structure, the oral phase of the swallow, the oral preparatory phase of the swallow, and the self esteem of the child.

Assessment of Motor-Speech Skills

•Robin, D.A., Yorkston, K.M., & Beukelman, D.R. (Eds.). (1996). *Disorders of motor speech: Assessment, treatment, and clinical characterization.* Baltimore: Paul H. Brookes Publishing Co.

•Hayden, D.A., & Square, P.A. (1994). Motor speech treatment hierarchy: A systems approach. *Clinics in Communication Disorders, 4,* 151-161.

•Davis, B., & Velleman, S L. (2000). Differential diagnosis and treatment of developmental apraxia of speech in infants and toddlers. *Infant-Toddler Intervention: The Transdisciplinary Journal, 10,* 177-192.

•Crary, M.A. (1995). Clinical evaluation of developmental motor speech disorders. *Seminars in Speech and Language, 16,* 110-125.

•Thoonen, G., Maassen, B., Gabreels, F., & Schreuder, R. (1999). Validity of maximum performance tasks to diagnose motor speech disorders in children. *Clinical Linguistics and Phonetics, 13,* 1-23.

•Williams, P., & Stackhouse, J. (2000). Rate, accuracy, and consistency: Diadochokinetic performance of young normally developing children. *Clinical Linguistics and Phonetics, 14,* 267-293.

•Williams, P., & Stackhouse, J. (1998). Diadochokinetic skills: Normal and atypical performance in children aged 3-5 years. *International Journal of Language and Communication Disorders, 33* (Suppl.), 481-486.

Assessment of Speech and Language Development

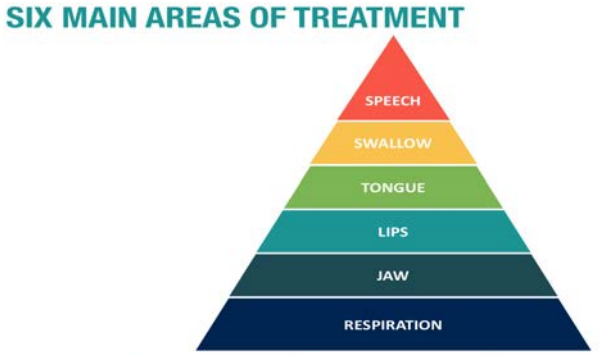
(Dyson, 1988; de Boysson-Bardies & Vihman, 1991; Broad, 1972; Broad, 1975; Guenther, 1995; Irwin, 1948; Irwin & Chen, 1946; Kent, Osberger, Netsell, & Hustedde, 1987; Mehrabian, 1970; Moore & Ruark, 1996; Oller, 1978; Oller & Eilers, 1988; Oller, & Yeni-Komshian, 1980; Robb & Bleile, 1994; Sander, 1972; Smit, 1986; Stoel-Gammon, 1985; Stoel-Gammon, & Cooper, 1984)

- Phonemic inventory
- From babbling to sentences
- Effects of feeding on speech development
- Respiratory kinematics during vocalization and non-speech respiration
- Sound acquisition, distortions, and omissions
- Overall intelligibility

Treatment of Disruptions in Mouth and Airway Development/Function

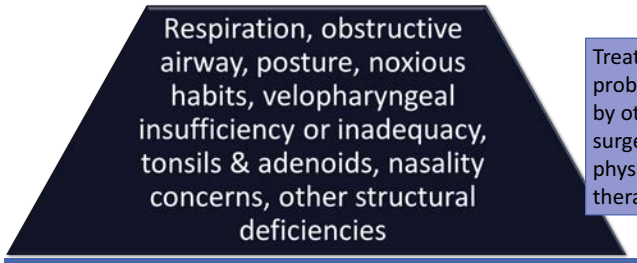
BIRTH TO AGE 7 YEARS

Hierarchy of Understanding



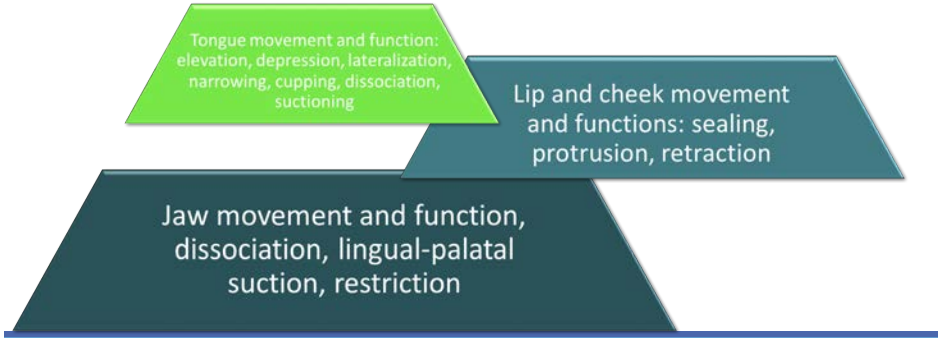
Treatment of Foundational Problems

(Alexander, 1987; Bahr & Johanson, 2013; Bueno, Grechi, Trawitzki, Anselmo-Lima, Felicio, & Valera, 2015; Camacho, et. al., 2015; Chuang, Lian, Hervy-Auboiron, Guilleminault, & Huang, 2017; Cook, et al., 1957; Bueno, Grechi, Trawitzki, Anselmo-Lima, Felicio, & Valera, 2015; Cerezo, Lobato, Pinkos, & LeLeiko, 2011; Diaferia, et al., 2017; Guilleminault & Huang, in press; Guilleminault & Sullivan, 2014; He, Stavropoulos, Hagberg, Hakeberg, & Hohlin, 2013; Ferres-Amat, Pastor-Vera, Ferres-Amat, Mareque-Bueno, Prats-Armengol, & Ferres-Padro, 2016; Marchesan, 2012)



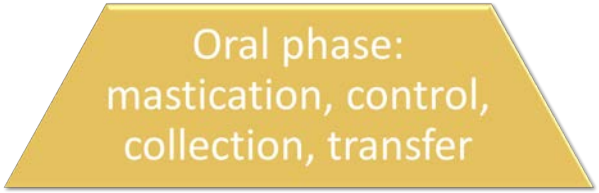
Treatment of foundational problems are typically performed by other professionals such as surgeons, dentists, chiropractors, physical therapists, occupational therapists, and others.

Treatment of the Jaw, Lip and Tongue Musculature and Physiology (He, Stavropoulos, Hagberg, Hakeberg, & Mohlin, 2013; Ferres-Amat, Pastor-Vera, Ferres-Amat, Mareque-Bueno, Prats-Armengol, & Ferres-Padro, 2016; Marchesan, 2012; Eckman, Williams, Reigel, & Paul, 2008; da Costa, Remijn, Weenen, Vereijken, & van der Schans, 2017; Green, Moore, Ruark, Rodda, Morvee, & Vanwitzenburg, 1997; Iguchi, Magara, Nakamura, Tsujimuar, Ito, & Inoue, 2015; Inoue, Sakashita & Kamegai, 1995; Le Reverend, Saucy, Moser, & Loret, 2016; Wada, Tohara, Iida, Inoue, Sato, & Ueda, 2012; Pizolato, Fernandez & Gaviao, 2009; Walsh, Links, Boss, & Tunkel, 2017; Tsaousoglou, Topouzelis, Vouros, & Sculean, 2016; Manipon, 2016; Leder, Suiter, Murray, & Rademaker, 2013; Ghaheri, Cole, Fausel, Chuop, & Mace; 2017)



Treatment of the Swallowing Deficits

(Gosa, Carden, Jacks, Threadgill, & Sidlovsky, 2017; Leder, Suiter, Murry, & Rademaker, 2013; Cichero, 2017; Moral, et. al., 2010; Morris, 2003; Steeve, Moore, Green, Reilly, & McMurtrey, 2008; Stevenson & Allaire, 1991; Volkert, Peterson, Zeleny, & Piazza, 2014)



Treatment of the Speech Sound Disorder, if applicable

(Broad, 1972; Broad, 1975; Grace, Oddy, Bulsara, & Hands, 2017; Hiiemae & Palmer, 2003; Dyson, 1988; Irwin, 1948; Irwin & Chen, 1946; Robb & Bleile, 1994; Sander, 1972; Smit, 1986; Stoel-Gammon & Cooper, 1984)

OPT = Oral Placement Therapy

References

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