3

Influence of the Infant's Anatomy and Physiology

INTRODUCTION

The newborn infant brings a unique set of anatomic structures, physiological activities, reflexive behaviors, and nutritional needs and stores to the breastfeeding relationship. The mechanical acts of latching, suckling, swallowing, and breathing must all occur in a synchronized interplay among anatomic structures, physiological parameters, and the infant's immediate environment. After birth, the fetus must transition to extrauterine life and undergo extraordinary changes in an amazingly short time. Some of these changes affect and are affected by breastfeeding. This chapter views breastfeeding from the perspective of the infant and the structures and functions that he or she brings to the breastfeeding process.

FUNCTIONAL INFANT ANATOMY AND PHYSIOLOGY ASSOCIATED WITH BREASTFEEDING

To breastfeed effectively, an infant must engage in and coordinate the three basic processes of suck, swallow, and breathe. Anatomic structures contributing to these processes are usually in close proximity to one another and may overlap in function (**Figure 3-1**). This topic is covered in depth by Wolf and Glass (1992) and Morris and Klein (2000). Knowledge of these structures, their functions, and their interrelatedness allows the clinician to assess the feeding process and to recognize anatomic or physiological deviations and how they affect the ability to breastfeed effectively (**Box 3-1**).

Oral Cavity

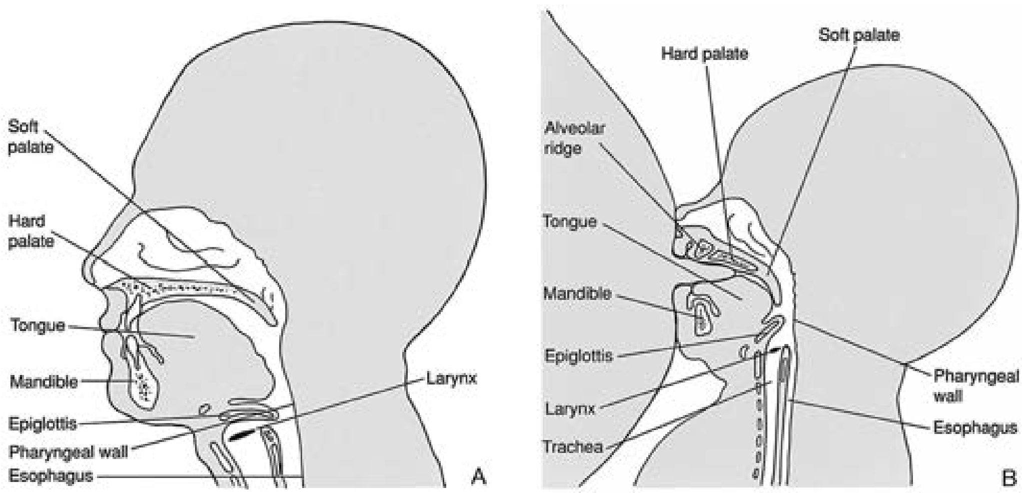
The oral cavity or the mouth consists of the lips, upper jaw (maxilla), lower jaw (mandible), cheeks, tongue, floor of the mouth, gum ridges, hard and soft palates, and uvula.

Lips and Cheeks

- The lips help locate the nipple and bring it into the mouth (not necessary with bottle-feeding).
- The lips stabilize the position of the nipple–areolar complex within the mouth.

FIGURE 3-1

Swallowing Anatomy: Midsagittal sections of the cranial and oral anatomy of an adult (A) and an infant (B) swallowing



Source: Riordan, J., & Wambach, K. (2010). Breastfeeding and human lactation (4th ed.). Sudbury, MA: Jones and Bartlett.

- The lips help form the anterior seal around the nipple–areolar complex.
- The cheeks provide stability and maintain the shape of the mouth.
- In young infants, the fat pads passively provide the majority of positional stability.
- As the infant grows, the fat pads diminish and the cheek muscles provide active stability.
- The cheeks provide lateral boundaries for food on the tongue and help in bolus formation.
- The fat pads are visible through 6–8 months of age.
- Fat pads are considerably diminished in preterm infants.

The labial or maxillary frenum (the terms "frenum" and "frenulum" are used interchangeably) attaches the upper lip to the upper gum. It has been defined as a vertical band of lip tissue extending from the inside portion of the upper lip and attaching to the alveolar mucosa of the maxillary arch (Kotlow, 2011a). A tight labial frenum or "lip-tie" may create difficulty flanging the upper lip and maintaining a seal on the breast (Wiessinger & Miller, 1995), possibly resulting in sore nipples, decreased milk intake, and engorgement, and later contributing to dental caries and creating a gap between the child's front teeth. A maxillary lip-tie has also been associated with reflux and colic-like symptoms in infants from swallowing excessive amounts of air due to the inability to form a tight seal around the breast while sucking (Kotlow, 2011b).

Mandible (Lower Jaw) and Maxilla (Upper Jaw)

- The jaw is innervated by cranial nerve V, the trigeminal (motor).
- It provides a base for movements of the tongue, lips, and cheeks.
- Downward movement during sucking expands the size of the sealed oral cavity to create suction.

BOX 3-1

Evaluation of Oral Structures

Tongue

Key Functions

Assists in sealing oral cavity anteriorly and posteriorly

Changes configuration to provide compression to nipple to increase volume of oral cavity for suction

Bolus formation

Normal Position and Movement

Position: Soft, with well-defined shape that is thin and flat with a rounded tip.

Rests in the bottom of the mouth, and not seen when the lips are closed.

Movement: Actively cups around the finger, forming a central groove.

Movements should be rhythmic, wavelike, and in small excursions.

Compression and suction should be present.

Abnormalities of Position and Movement

Position: Protruding out of the mouth, retracting into the mouth, or humped/bunched with a thick feeling. Tip should not be elevated against the palate.

Movement: Protrusion or thrusting during sucking, lack of central grooving, arrhythmic movements.

Jaw

Key Functions

Provides a stable base for movements of the tongue

Helps create negative pressure by slight downward movement

Normal Position and Movement

Position: Upper and lower alveolar ridges are aligned, with loose opposition.

Movement: Smooth, rhythmic movement in small excursions.

Abnormalities of Position and Movement

Position: Hanging open, clenched tightly, or lower jaw retracted (micrognathia)

Movement: Wide or excessive jaw excursion, clenching or biting during sucking

Lips

Key Functions

Assist in forming anterior seal

Assist in stabilizing nipple position

Normal Position and Movement

Lips are soft, shape to the nipple, and provide slight pressure at corners.

Abnormal Position and Movement

Loose and floppy with poor seal around nipple, or tight and pursed

Cheeks

Key Functions

Provide stability to oral cavity

Aid in bolus formation

(continues)

BOX 3-1

Evaluation of Oral Structures *(continued)*

Normal Position and Movement
Fat pads visible, soft profile, with little movement during sucking

Abnormalities of Position and Movement
Floppy or stiff, pulling in during sucking

Palate
Key Functions
Hard palate: Helps compress nipple, maintains nipple position
Soft palate: Assists in creating posterior seal, elevates during swallow

Normal Position and Movement
Hard and soft palates should be intact with smooth contours.

Abnormalities of Position and Movement
Clefts of any portion of the palate, high arched hard palate, bifid uvula, decreased movement of soft palate

Source: Glass, R. P., & Wolf, L. S. (1994). A global perspective on feeding assessment in the neonatal intensive care unit. *American Journal of Occupational Therapy*, *48*(6), 514–526. © 1994 by the American Occupational Therapy Association, Inc. Reprinted with permission.

- A receding jaw positions the tongue posteriorly, where it can lead to obstruction of the airway.
- A receding jaw can contribute to sore nipples unless the chin is brought closer to the breast.
- Breastfeeding creates beneficial forces on the development of the jaws during a period of very rapid growth. The forward forces of suckling (as in breastfeeding) oppose the backward forces of sucking (as in bottle-feeding) (Page, 2001). Breastfeeding helps correct physiological mandibular retrognathism (the normal slightly retracted mandible that usually self-corrects during growth, due to the jaws increasing in size). Bottle-feeding causes the buccinator muscle (used for obtaining milk from a bottle) to become hypertrophic (enlarged or overgrown), which can alter the growth trajectory of the mandible and maxilla (Carrascoza, Possobon, Tomita, & Moraes, 2006). Breastfeeding allows the masseter muscle (the principal muscle of breastfeeding), which elevates the mandible, to strengthen and grow appropriately for facilitating normal craniofacial growth. This development also allows for the ideal positioning of the mandible for tooth eruption (Gomes, Thomson, & Cardoso, 2009).
- Sanchez-Molins, Carbo, Gaig, and Torrent (2010) found that breastfeeding had a very positive influence on the growth of the orofacial structures compared to bottle-feeding. Craniofacial features were compared in breastfed and bottle-fed 6- to 11-year-old children. Bottle-fed children showed a more retrusive mandible, with facial growth described as dolichocephalic (or long face). Breastfed children had a mandibular arch that determined a more brachycephalic growth (or short face).
- Medeiros, Ferreira, and de Felicio (2009) reported that 6- to 12-year-old children who had been breastfed had better mobility of the tongue and jaw than children who had been bottle-fed. The enhanced orofacial structures showed breastfed children performing better in tests of speech repetition, chewing and swallowing, and lip, tongue, and mandible mobility, compared with children who had been bottle-fed as infants.

Tongue

- The tongue is innervated by:
  - Cranial nerve VII, facial (sensory)
  - Cranial nerve IX, glossopharyngeal (taste)
  - Cranial nerve XII, hypoglossal (motor muscles of the tongue)
- During breastfeeding the tongue actively brings the nipple into the mouth, shapes the nipple and areola into a teat, and stabilizes the teat's position.
- During bottle-feeding the tongue is not needed to draw the artificial nipple into the mouth, but the tongue still helps stabilize the position of the nipple.
- The tongue helps seal the oral cavity (the anterior portion along with the lower lip seal against the nipple–areolar complex, while the posterior portion seals against the soft palate until the soft palate lifts for swallowing).
- By changing configuration, the tongue is the primary means of increasing the volume of the oral cavity to create negative pressure/suction.
- The tongue provides compression against the nipple–areolar complex or teat (Bosma, Hepburn, Josell, & Baker, 1990).
- The tongue forms a central groove to channel liquid toward the pharynx, and the lateral portions of the tongue elevate and curl to provide the framework or a cylindrical pathway for the movement of milk (Tamura, Horikawa, & Yoshida, 1996).
- The neonatal tongue differs morphologically from the adult tongue in that it is specialized for suckling, especially in the adaptation that allows the curling of the lateral edges of the tongue (Iskander & Sanders, 2003).
- The tongue helps form a bolus and holds it in the oral cavity until swallowing is triggered.
- The lingual frenulum is a fold of mucous membrane that extends from the floor of the mouth to the midline of the undersurface of the tongue, anchoring the tongue to the base of the mouth. Tongue functioning can be impaired if the frenulum is tight or short.

Carrascoza and colleagues (2006) studied the effects of the use of feeding bottles on the oral facial development of children who were breastfed and those who were bottle-fed. They reported the following:

- The tongue of bottle-fed infants tended to rest in the mandibular arch, indicating somewhat hypotonic tongue muscles compared with the resting position of the tongue of breastfed infants. The tongue of breastfed infants normally rests in the maxillary arch.
- Sucking movements of breastfeeding place the tongue in the palatal region of the central incisors, preventing air from passing through the mouth, which favors nose breathing. While this type of breathing heats, humidifies, and filters air prior to reaching the lungs, it is also considered the functional matrix for growth of the maxilla. The passage of air through the nose exerts pressure on the palate, resulting in the lowering and expanding of the structure, which allows the face bones to accompany general body growth.
- In bottle-fed infants, the tongue rests in an unphysiological position that promotes mouth breathing and discourages nose breathing. The result can be maxillary atresia (narrowing of the maxilla and a V-shaped palate rather than a U-shaped palate), compromise of the esthetic appearance and function of the nose, and alteration of the shape of the face

Hard Palate

Wolf and Glass (1992) describe the hard palate's functions as assisting with the positioning and stability of the nipple when drawn into the mouth and working in conjunction with the tongue in the compression of the nipple–areolar complex. The contour of the palate is shaped in utero and after birth by the continuous pressure of the tongue against the palate when the mouth is closed. A palate with a high arch or one that is very narrow may be an indication of an abnormality or a restriction of tongue movement.

Palmer (1998) described the palate as being almost as malleable as softened wax while in the early stages of oral cavity development. It can therefore be subject to alterations, depending on what is placed in the mouth (artificial nipples, intubation, pacifiers). Pressure from objects can easily mould the shape of the palate. The soft human breast in the infant's mouth contributes to a rounded U-shaped palatal configuration, because the flexible and supple breast flattens and broadens in response to the infant's tongue action. An appropriately shaped palate aligns the teeth properly and does not infringe upward, thus avoiding a contributing factor to reducing the size of the nasal cavity.

Snyder (1995) describes size parameters of the reference palate as being 0.75 inch (2 cm) in width (as measured from the lateral aspects of the alveolar ridges midway to the junction of the hard and soft palates) and approximately 1 inch (2.5 cm) from the anterior superior alveolar ridge to the hard and soft palates' junction. Wilson-Clay and Hoover (2002) measured the palates of 98 infants ranging in age from 35 weeks of gestation to age 3 months by inserting a gloved finger to a depth that triggered sucking. The length from lip closure to the hard and soft palates' juncture ranged from 0.75 to 1.26 inches (1.9–3.2 cm). Palatal variations have been described as narrow, grooved or channeled, high, flat, V-shaped, short, long, and bubble.

Hohoff, Rabe, Ehmer, and Harms (2005) describe the hard palate of the newborn as already exhibiting rugae (ridges or folds), which are also present on the adult hard palate. These rugae or ridges are thought to help anchor the breast in the mouth so it does not slip or slide out of position during sucking (Crelin, 1976). The maxilla of the newborn is further characterized by a system of grooves (**Figure 3-2**). By the age of 5 years, the lateral palatine ridges are no longer apparent and the palate becomes similar to that of the adult. Epstein's pearls are white or yellow inclusion cysts that may be present on the palate and are remnants of epithelial tissue trapped during palatal fusion. These cysts generally disappear within a few weeks of birth.

Soft Palate (Velum)

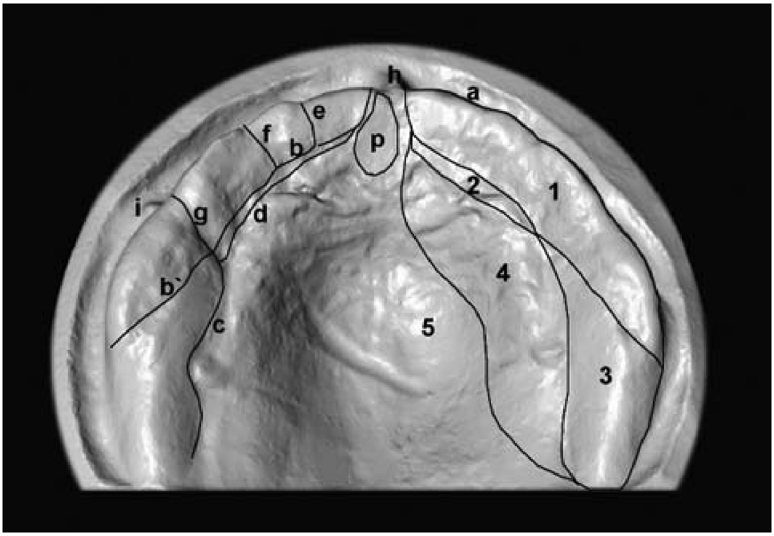
The soft palate is continuous and extends directly posterior to the hard palate. It does not have a bony core but rather a layer of fibrous tissue called the palatine aponeurosis, to which all soft palate musculature is attached. The soft palate makes up the posterior third of the palate, is fleshy and moveable, and raises during swallowing so that food passes into the esophagus and not up into the nasal cavity. The boundary between the hard and soft palates has traditionally indicated how far back into the mouth the nipple should extend at maximum suction. However, Jacobs, Dickinson, Hart, Doherty, and Faulkner (2007) demonstrated under ultrasound that only about 25% of infants in their study positioned the nipple at exactly the junction of the hard and soft palates. The mean distance from the tip of the nipple to the junction of the hard and soft palates was 5 mm in breastfeeding couples with no nipple pain or milk transfer issues, which illustrated that most infants did not draw the nipple–areola as far into the mouth as once thought. The nipple was not stationary during feedings, with a movement of 4.0 ± 1.3 mm. Hanging from the posterior edge of the soft palate is the uvula, which contains some muscle fibers.

Nasal Cavity

Inspired air passes through the nasal cavity, where the palatine bone or hard palate separates the oral cavity from the nasal cavity. The opening to the eustachian tube is present in this area (nasopharynx). The nasal cavity is sealed off from the oropharynx and oral cavity when the soft palate is fully elevated.

FIGURE 3-2

Newborn Palate



Nomenclature of Palatal Structures

a	outer alveolar groove	h	frenum labii
b	alveo-palatinal sulcus	i	frenulum of cheek
b′	postero-lateral sulcus	p	papilla incisive
b + b′	tooth germ groove	1	alveolar wall
c	transitory palatal fold	2	tektal wall
d	anterior palatal groove	3	dental molar wall
e	anterior sulcus	4	lateral palatine ridge
f	antero-lateral sulcus	5	palatal vault
g	lateral sulcus		

Source: Hohoff, A., Rabe, H., Ehmer, U., & Harms, E. (2005). Palatal development of preterm and low birthweight infants compared to term infants—What do we know? Part 1: The palate of the term newborn. *Head and Face Medicine, I,* 8. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1308841/?tool=pubmed.

Pharynx

The pharynx, a soft tube involved in swallowing, is divided into three regions: the nasopharynx; the oropharynx, which is the space between the elevated soft palate and the epiglottis; and the hypopharynx or laryngeal pharynx, which is the area and the structures between the epiglottis and the sphincter at the top of the esophagus. Changes in head position (flexion, extension, sideways movement) influence the diameter of the pharynx, which is thought to be related to protection of the airway.

Larynx

The larynx is composed primarily of cartilage and contains structures necessary for producing sounds and protecting the airway during swallowing. The epiglottis is a structure that rests at the base of the tongue and folds down during swallowing to close and seal off the inlet to the larynx and trachea, thereby preventing liquid and food from entering the airway. At rest, it is elevated and allows air to flow freely through the larynx into the trachea.

Trachea

The trachea is a semirigid tube composed of semicircular rings of cartilage connected to each other and to the larynx. As it descends, it branches into the two primary bronchi that go to each lung.

Hyoid Bone

The hyoid is a small, free-floating bone that is the nexus of connections between the structures involved in the anatomy and physiology of sucking, swallowing, and breathing as well as in head and neck control. The hyoid is held in position by seven connections: to the scapula, sternum, cervical vertebrae, laryngeal cartilage, tongue, mandible, and temporal bone. When the hyoid moves up and forward during swallowing, the appropriate connections help open the entry to the esophagus. The muscles attached to the hyoid are involved in the bulk of mechanical breastfeeding behaviors, and their ability to function optimally depends on the position of the head and neck. Movement of the hyoid bone is a direct indication of swallowing. Abnormal movement of the hyoid is considered an indication of a sensory-deficit or abnormal motor response (Sonies, Wang, & Sapper, 1996).

Esophagus

The esophagus is the tube through which food passes on its way to the stomach, propelled by smooth and striated muscles that create peristalsis. It terminates at the stomach at the lower esophageal sphincter, which relaxes during peristalsis to allow food or fluid to enter the stomach. The lower esophageal sphincter remains closed at rest and provides protection from the upward flow or reflux of stomach contents into the esophagus. The oral, pharyngeal, and laryngeal structures are in close proximity during the early months of life. Because these structures and functions are interrelated, structural defects or disorganized functional problems in one area may adversely affect other areas.

Muscles

More than 40 muscles participate in the complex process of coordinating the movement of food and air through the oral cavity. Muscles act in synchrony and function to effect lip movement, allow graded jaw movements, influence the shape and action of the tongue and cheeks, elevate the soft palate to seal the nasopharynx, protect the airway, and move and clear a bolus of food.

Neural Control

Just as the anatomic structures and functions of suck, swallow, and breathe overlap, so too do the nerves that innervate these structures and functions. Six cranial nerves overlap in neural function to enable the suck, swallow, and breathe functions (**Table 3-1**).

Reflexes

Full-term infants come equipped with a number of well-developed reflexes that aid in securing food in a safe and efficient manner.

- Swallowing is seen in the fetus as early as 12 weeks of gestation. Infants are born with considerable experience in swallowing from the routine ingestion of amniotic fluid before birth.

TABLE 3-1

Cranial Nerves Associated with Suck, Swallow, and Breathe

Cranial Nerve	*Function*
I—Olfactory nerve (sensory)	Responsible for the sense of smell, which also affects the perception of taste.
V—Trigeminal (sensory and motor) ■ Maxillary branch ■ Mandibular branch ■ Ophthalmic branch (purely sensory and not involved with sucking, swallowing, or breathing)	Channels sensory information from the mouth (suck), soft palate (swallow), nose (breathe) Gathers sensory input from the cheeks, nose, upper lip, teeth Gathers sensory input from the skin over the lower jaw, the lower lip, and lower teeth Motor aspect of the nerve innervates muscles that control chewing.
VII—Facial (sensory and motor)	Sensory fibers on the anterior two-thirds of the tongue for sweet, salty, and sour tastes. The motor fibers are involved with the muscles of facial expressions and the salivary glands.
IX—Glossopharyngeal (sensory and motor)	Sensory fibers on the posterior third of the tongue for bitter taste. Motor fibers go to the muscles used in swallowing, to the salivary glands, and innervate the gag reflex.
X—Vagus (sensory, somatic, and autonomic)	Sensory information from the palate, uvula, pharynx, larynx, esophagus, visceral organs. Motor connections to the pharynx, larynx, and heart. Autonomic nervous system functions are involved in heart rate, smooth muscle activity in the gut, glands that alter gastric motility, respiration, and blood pressure.
XII—Hypoglossal (motor)	Contraction of the muscles of the tongue. Involved in the peristaltic action in bolus preparation, sucking, and swallowing.

Source: Walker 2e

- Sucking is present by 24 weeks of gestation, with the fetus being capable of turning his or her head toward oral stimulation. Sucking is initiated by stimulation in the infant's mouth that causes the infant to extend his or her tongue over the lower gum, raise the mandible, draw the nipple–areola into his or her mouth, and initiate the sequence of sucking behaviors. Sucking is a reflex at birth, with the infant "obligated" to suck on anything placed in the mouth. By about 3 months, sucking changes from reflexive or automatic to voluntary. Some parents see this transition as a breastfeeding infant who refuses to suck on artificial nipples (even if they have been given in combination with breastfeeding since early after birth).
- The gag reflex is apparent at 26 weeks of gestation and is quite strong in a newborn. At first it can be stimulated when the posterior two-thirds of the tongue is touched. It gradually changes such that the gag reflex is elicited farther back on the posterior one-third of the tongue.
- The phasic bite and transverse tongue reflexes appear at around 28 weeks of gestation. The phasic bite reflex is seen as the rhythmic opening and closing of the jaw when the gums are stimulated. The transverse tongue reflex is seen as the tongue gravitating toward a stimulus, elicited by tracing the lower gum ridge and brushing the lateral edge of the tongue with the examiner's finger.

- The rooting reflex is seen at 32 weeks of gestation and occurs in response to stroking of the skin around the mouth. This mouth-orienting reflex is strongest around 40 weeks and fades after 3 months.

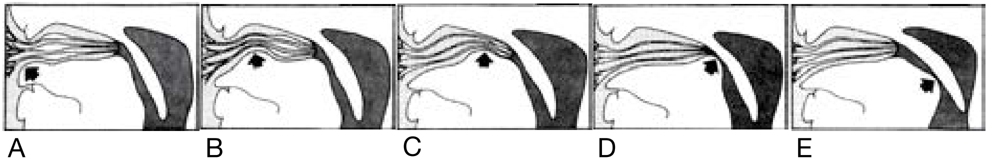
Sucking Mechanisms

Components of sucking, swallowing, and breathing, along with the coordination between the three activities, mature at different times and rates depending on the gestational age of the infant. For example, expression (positive pressure) matures before suction. These activities also need to occur sequentially from the oral phase to the pharyngeal (swallowing) phase to the pulmonary or breathing phase while ensuring that the swallow takes place during a safe phase of the respiratory cycle (Amaizu, Shulman, Schanler, & Lau, 2008). Sucking at the breast involves a complex series of behaviors that have been studied for a number of years by various means. Changing research modalities have allowed researchers and clinicians to refine their understanding of how this process unfolds.

- Ardran, Kemp, and Lind (1958) were among the first researchers to visualize the breast inside the infant's mouth. In their study the breast was coated with a barium sulfate paste, and radiographic films were made while the infant nursed. Infants were positioned on a couch with the mother leaning over the baby, which may have prevented a deep latch and partially accounted for observations that have since been refined with newer imaging techniques. Notable was the confirmation that the nipple and areola were drawn into the mouth to the junction of the hard and soft palates and that the nipple widened and extended to about three times its resting length, forming the nipple–areolar complex or a teat. These authors also described the action of the infant forming the nipple–areola into a teat and drawing it far back into the mouth, with the tongue playing a major part in the sucking process and the breast being soft and pliable enough to allow this activity. According to these authors, "Any factor which causes edema or congestion [of the breast] will probably interfere with suckling." Their study was confined to the lateral plane and could not visualize other tongue actions. It also relied on x-rays, the hazards of which halted the use of this type of research.
- The use of real-time ultrasound refined the interpretation of the sucking process at breast. Smith, Erenberg, Nowak, and Franken (1985) and Smith, Erenberg, and Nowak (1988) noted the following points:
    1. Failure of the lips to form a complete seal is manifested on a scan by air leaking into the oral cavity.
    2. Tongue and jaw movements compress the nipple, which is highly elastic, elongating it along with 2 cm of areola to twice its resting length and to 70% of its original diameter.
    3. During the peristaltic action of the tongue, the teat is compressed 60% more in the vertical direction and widens by 20% in the lateral direction.
    4. The buccal mucosa and musculature (sucking pads, buccinator muscle) move inward as the tongue is depressed. This maintains a tight seal on the nipple–areola, conducts the milk toward the central depression in the posterior portion of the tongue, and allows the milk to be propelled toward the oropharynx.
- Weber, Woolridge, and Baum (1986) described both feeding movements and the coordination of sucking, swallowing, and breathing:
    1. The action of the tongue in a breastfed infant was described as a rolling or peristaltic undulation in an anterior to posterior direction, whereas in bottle-fed infants the tongue worked in an up-and-down piston-type motion; when not sucking, the breastfed infants maintained their grasp on the nipple, with the teat still moderately indented by the tongue.
    2. The lateral margins of the tongue cupped around the nipple, forming a central groove.

FIGURE 3-3

Complete Suck Cycle on Breast



A. The suck cycle is initiated by a welling up of the anterior tip of the tongue. Simultaneously, the lower jaw rises to constrict the base of the nipple, "pinching off" milk within the ducts of the teat.
B. The tongue moves along the underside of the nipple, pushing against the hard palate. This wavelike action squeezes milk from the nipple.
C and D. This wave of compression passes beyond the tip of the nipple, pushing against the soft palate. The levator muscles of the palate contract and rise to seal off the nasal cavity.
E. The cycle ends at the posterior base of the tongue. Tongue compression and negative pressure within the mouth maintain the tongue in close conformation to the nipple and the palate, drawing milk into the mouth. A lowering of the jaw allows milk back into the nipple.

Source: Lauwers, J., & Swisher, A. (2011). *Counseling the nursing mother: A lactation consultant's guide* (5th ed.). Sudbury, MA: Jones & Bartlett Learning.

3. One- to 3-day-old infants showed distinct interruptions of their breathing movements when a swallow occurred, whereas in infants 4 days and older, the breathing trace appeared as a smooth uninterrupted movement with swallows occurring at the natural boundary between expiration and inspiration.

Figure 3-3, a graphic rendering of ultrasound studies, summarizes the dynamics of a complete suck cycle that was postulated from this study (Woolridge, 1986).

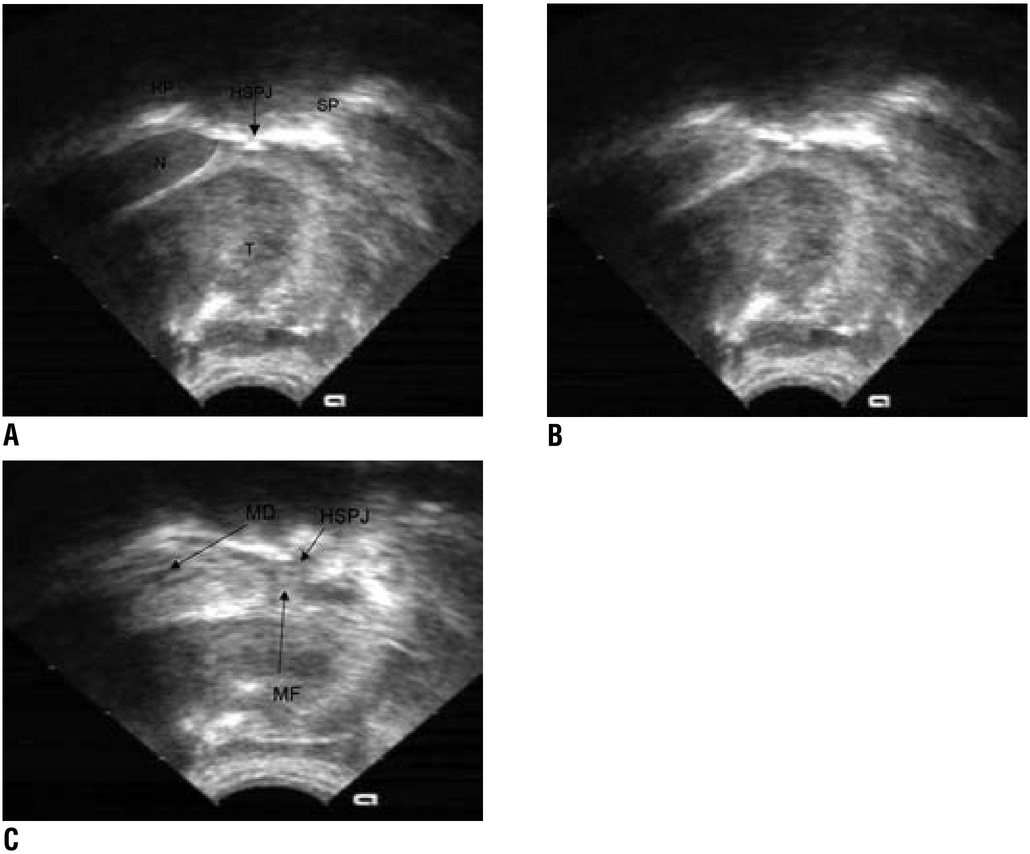
Woolridge and Drewett (1986) also noted the importance of taking into account both positive and negative pressures. Fluid movement during breastfeeding occurs from an area of high pressure inside the breast—created by fluid volume and the milk ejection reflex—to an area of low pressure inside the infant's mouth, where suction or vacuum is created by sealing the oral cavity and enlarging it when the jaw and tongue drop. During bottle-feeding, either suction or compression can be the predominant determinant of efficient fluid flow, depending on the type of nipple and opening in the nipple. Preterm infants are able to express milk from a bottle without applying vacuum (Lau, Sheena, Shulman, & Schanler, 1997), and although they may effectively feed from a bottle, they can demonstrate difficulty in removing milk from the breast. This finding suggests that the mechanics of milk removal from a bottle versus from the breast are different (Meier, 2003). Although infants can receive some milk by compressing an artificial nipple, in the absence of negative pressure (i.e., in infants who cannot develop sufficient suction), adequate amounts of milk may be lacking unless modifications are made to the nipple.

Current, more sensitive ultrasound studies describe the infant sucking dynamic (**Figures 3-4 and 3-5**) as follows (Geddes, Kent, Mitoulas, & Hartmann, 2008; Jacobs et al., 2007):

- Negative pressure draws the nipple–areola into the mouth, usually several millimeters anterior to the junction of the hard and soft palates, forms a teat, and holds it in place with a baseline vacuum of –60 mm Hg over the entire breastfeeding.

FIGURE 3-4

Ultrasound Images of Intra-Oral Cavity During Breastfeeding

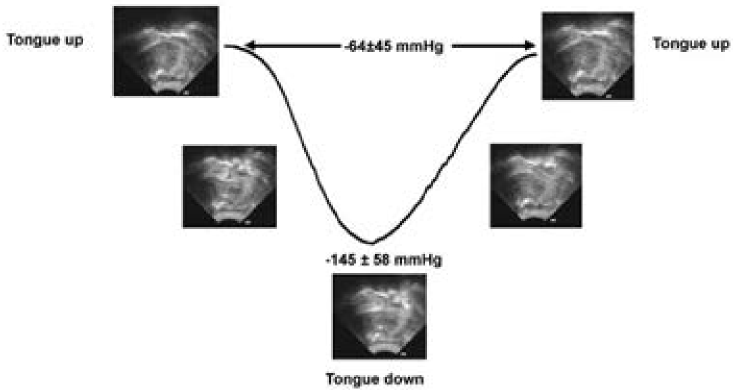


Source: Reprinted from Geddes, D. T., Kent, J. C., Mitoulas, L. R., & Hartmann, P. E. (2008). Tongue movement and intra-oral vacuum in breastfeeding infants. *Early Human Development, 84,* 7.

- The motion of the tongue during a suck cycle does not show a peristaltic action (as in bottle-feeding), but rather the tongue is up and in apposition with the hard palate, with the anterior tongue not indenting the nipple.
- Vacuum is generated as the tongue and jaw move down, which allows milk flow from the nipple. When the posterior part of the tongue lowers, milk ducts in the nipple open and milk flows into the infant's mouth. Peak vacuum coincides with the tongue at its lowermost position.
- As the tongue moves back up, vacuum decreases and milk flow ceases. Milk ducts within the nipple and milk flow cannot be seen on ultrasound. The tongue captures the milk that has flowed into the nipple, holding it in place until the tongue and jaw lower again, with the milk subsequently flowing

FIGURE 3-5

Changes in Infant Tongue Position During One Complete Suck Cycle



Source: Reprinted from Geddes, D. T., Kent, J. C., Mitoulas, L. R., & Hartmann, P. E. (2008). Tongue movement and intra-oral vacuum in breastfeeding infants. *Early Human Development, 84,* 7.

into the oral cavity. This mechanism ensures that milk is not constantly flowing into the oral cavity but is apportioned into manageable boluses so that excessive swallowing does not interfere with breathing and oxygenation.

McClellan, Sakalidis, Hepworth, Hartmann, and Geddes (2010) investigated infant sucking using ultrasound and measured the nipple diameter and placement of the nipple within the infant oral cavity during breastfeeding. They found that the nipple diameter does not remain consistent along the length of the nipple during sucking, and changes in nipple diameter associated with tongue movement were also significantly different. All nipple diameter measurements significantly increased between the tongue-up and tongue-down movements, which the authors concluded was not consistent with a peristaltic tongue action. Sakalidis and colleagues (2012a) found that there was a difference in tongue movement between nutritive and non-nutritive sucking at the breast. During nutritive sucking, the infant's midtongue lowered farther and the sucking was significantly slower compared to non-nutritive sucking.

In contrast, using ultrasound videos to describe the sucking sequence, Monaci and Woolridge (2011) reported that during non-nutritive sucking prior to eliciting the milk ejection reflex, the infant's tongue engaged in a peristaltic motion. After the milk ejection reflex, a swallow was seen corresponding to each suck and a more pronounced vacuum action (tongue depression) was seen, similar to the previously discussed description of Geddes and Jacobs. Therefore it is thought that infants may use both a peristaltic tongue action to move the milk into the oropharynx and a tongue depression to generate vacuum, which allows milk from the breast to enter the oral cavity of the infant (Woolridge, 2011). Woolridge (2012) identified both propulsive or peristaltic movements of the tongue as well as extractive or vacuum application during feedings at the breast. While each of the two types of tongue movements may be capable of removing milk independently, they are more likely to complement each other and act synergistically to accomplish the most efficient method of removing milk from the breast. Thus sucking seems to be a dynamic process, shifting between peristaltic movements and vacuum-generating movements, possibly in response to the varying rate of milk release from the breast. Vacuum-generating movements of the tongue may be superimposed on the peristaltic movements of the tongue and are generated as part of the same practice. Mothers can remove milk by positive pressure only, as with manual expression and the milk ejection reflex, or by negative pressure, as with a breast pump. However, unless milk ejection occurs (positive pressure) when using a pump, mothers may not express very much milk. Vacuum seems to be the driving force working in concert with an intact milk ejection reflex to ensure maximum milk expression when using a breast pump. Mothers using a breast pump experience maximum milk yield in the shortest time when using the highest comfortable vacuum. Most of the milk is collected during the first two milk ejections, occurring on average within the first 8 minutes after the start of the first milk ejection (Kent et al., 2008). Whereas too little vacuum may be problematic in removing milk from the breast, too much vacuum has also been shown to present potential problems. McClellan et al. (2008) studied two groups of mothers: those experiencing nipple pain during or after feedings and a control group with no complaints of pain. In spite of ongoing professional help by International Board Certified Lactation Consultants, infants of mothers with persistent nipple pain applied significantly stronger vacuums and transferred less milk than infants not causing pain. All components of the suck cycle were stronger, with the baseline vacuum or seal on the breast 61% stronger and the peak vacuum being 31% stronger in the infants causing the persistent nipple pain. These infants also applied more vacuum than an electric breast pump at the mothers' maximum comfort vacuum values. Mothers maintained their milk supply through expressing breastmilk if their nipples were too painful for direct breastfeeding.

Surface electromyography has shown differences in facial muscle activity between breastfeeding and bottle-feeding (Gomes, Trezza, Murade, & Padovani, 2006). Cup feeding is closer to breastfeeding than is bottle-feeding, relative to the use of facial muscles during feeding. The masseter muscle is important in infant feeding, especially because its movements govern the growth and positioning of the jaw. Bottle-feeding reduces masseter muscle activity, increases buccinator activity, reduces jaw movements, and causes the tongue to retract. Jacinto-Goncalves, Gaviao, Berzin, de Oliveira, and Semeguini (2004) reported differences in the profiles of muscles used in sucking between breastfed and bottle-fed children. Breastfed children presented higher activity for the mentalis and smaller activity of the orbicular oris muscle compared with bottle-fed children. This effect persisted out to 3.5 years, which was the duration of the study.

Quantifying the Sucking Episode

A number of infant sucking and breast functioning parameters have been measured that are of interest in the understanding of sucking as well as in the assessment of what is in the range of normal and what may constitute a deviation or alteration from the norm (**Table 3-2**).

Sucking patterns change over the course of a feed. The typical 1:1 ratio of sucking to swallowing changes by the end of a feed to a ratio of 2:1 or 3:1 sucks per swallow (Weber et al., 1986). The amount of milk transferred tends be higher from the first breast suckled and lower from the second breast. Prieto et al. (1996) showed a 58% decrease in amount of milk transferred from the second breast compared with the first: 63 ± 9 g from the first breast and 27 ± 8 g from the second breast in infants aged 21–240 days. Drewett and Woolridge (1981) measured 38.5 g from the first breast and 21.8 g from the second breast in 5- to 7-day-old infants. The volume of milk per suck also changes, with more than a 50% reduction from peak volume seen at the end of the feed on the second breast. The intake of the infants in these studies was not limited by the milk supply available but rather by the behavior of the infant in regulating his or her own intake.

TABLE 3-2

Infant Sucking and Breast Functioning Parameters

Parameter	*Value*	*Reference*
Infant negative pressure ranges		
Mean pressure	–50 ± 0.7 mm Hg	Prieto et al., 1996
Average range of pressure	–50 to –155 mm Hg	
Maximum pressure range	–197 ± 1 to –241 mm Hg	
Basal resting pressure to keep nipple in mouth	–70 to –200 mm Hg	
Infant positive pressure ranges		
Baby's tongue	73–3.6 mm Hg	
Baby's jaw	200–300 g	Kron & Litt, 1971
Full breast	28 mm Hg	Egnell, 1956
Additional pressure of milk ejection reflex	10 to 20 mm Hg	
Infant mechanics		
Cycles (sucks)	36–126 (mean 74) per minute	Bowen-Jones, Thompson, & Drewett, 1982
Duration of a suck	0.77 second (s)	Chetwynd, Diggle, Drewett, & Young, 1998
Duration of rest	0.7 s	
Sucks per second	1.28	Ramsay & Gisel, 1996
Intersuck interval	0.5–0.6 s with no milk flow 0.9–1.0 s at a flow rate of 0.5 g/suck	Woolridge, How, Drewett, Rolfe, & Baum, 1982; Bowen-Jones et al., 1982
Volume of milk per suck	0.14–0.21 mL at beginning of a feed 0.01–0.04 mL at the end of a feed	Chetwynd et al., 1998
Number of sucks per burst at beginning of feed	11 (with considerable variation)	Chetwynd et al., 1998
Number of sucks per burst at end of feed	5 (with considerable variation)	Shawker, Sonies, Stone, & Baum, 1983
Velocity of peristaltic wave motion of the tongue	15 cm/second	
Breast function parameters		
Mean diameter of lactiferous ducts before milk ejection	2.83 mm (range 1.1–5.9 mm)	Kent, Ramsay, Doherty, Larsson, & Hartmann, 2003
Increase in cross-sectional area of ducts following milk ejection	6.45 mm ± 0.98 mm	Kent et al., 2003
Length of time ducts remain dilated per each milk ejection	86 seconds	Ramsay, Kent, Owens, & Hartmann, 2001
Average yield for each milk ejection	35 g	Ramsay et al., 2001
Milk flow rate from breast	24.4 g/minute	Ramsay et al., 2001
Time from beginning of sucking to milk ejection	56 s	Kent et al., 2003
Time to milk ejection with pump	121 ± 11 s to 149 ± 12 s	Kent et al., 2003

Source: Walker 2e

Infants suck in bursts separated by rests, typically defined as a sequence of sucks with intersuck intervals of less than 2 seconds (Woolridge & Drewett, 1986). The sucking rate on the breast varies as a function of milk flow rate (Bowen-Jones, Thompson, & Drewett, 1982); the higher the milk flow rate, the slower the sucking rate. The intersuck intervals (within bursts) range from 0.5 to 1.3 seconds depending on milk flow rates, leading these researchers to conclude that there was not a distinct separation of nutritive and non-nutritive sucking at breast (as with bottle-feeding) but rather a graded distribution between the two. Ramsay and Gisel (1996) measured a higher sucking rate in breastfed infants compared with bottle-fed infants and showed that infants spent 50% more time sucking when they were alert than when they were asleep. Also noted was that infants identified in this study as having feeding difficulties demonstrated shorter continuous sucking bursts and shorter sucking times than infants who had no problems feeding. Infants who later showed some feeding difficulties were already exhibiting poorer feeding ability shortly after birth.

Bromiker et al. (2006) demonstrated that full-term infants of insulin-managed mothers with diabetes had poorer sucking patterns. These infants averaged 5.2 fewer sucking bursts and 42 fewer sucks per 5-minute interval. This finding is consistent with descriptions by Pressler, Hepworth, LaMontagne, Sevcik, and Hesselink (1999) of significantly poorer performance for motor processes and reflex functioning in infants of insulin-managed mothers with diabetes. These infants may be less neurologically mature, which would help explain the decrease seen in the number of sucks and number of bursts per 5-minute interval. Thus clinicians may wish to monitor these infants more closely, especially during the early days when breastfeeding is being established.

Moral and colleagues (2010) found that in 3- to 4-week-old infants who were exclusively bottle-fed, the mechanics of sucking showed fewer suck movements and the same number of pauses but of longer duration when compared to exclusively breastfed infants. In infants who were mixed fed (by both bottle and breast) there were 8.7% fewer suction movements compared to exclusively breastfed infants. Aizawa, Mizuno, and Tamura (2010) found that jaw and throat region movements differ between breastfed and bottle-fed infants. Jaw and throat region movements were significantly smaller during breastfeeding than during bottle-feeding. The angle of the mouth during breastfeeding was larger than during bottle-feeding. These differences were partly due to the difference in the angle of the mouth demonstrated during each type of feeding. These studies refute some of the marketing claims of artificial nipples being advertised as equivalent to feeding at the breast.

Ramsay, Kent, Owens, and Hartmann (2001) found that milk intake was related to the number of milk ejections experienced by the mother rather than the total time an infant spent at the breast. Each milk ejection makes a certain amount of milk available to the infant, whereas the vacuum applied by the infant affects how fast this milk is removed.

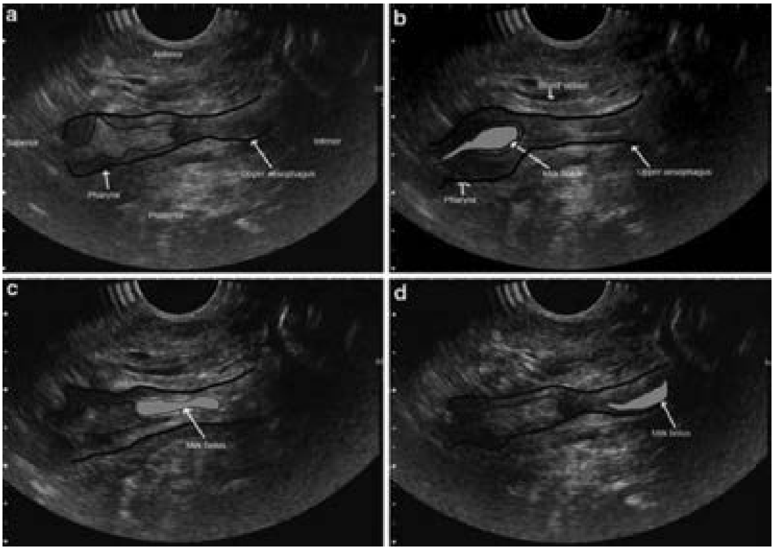
Swallowing

More than two dozen muscles are involved in the process of swallowing. Coordination of swallowing with suck and breathing is fundamental to effective and safe feeding. There are three phases of swallowing: oral, pharyngeal, and esophageal. The pharyngeal swallow is thought to achieve rhythmic stability as early as 32–34 weeks of gestation (Gewolb, Vice, Schweitzer-Kenney, Taciak, & Bosma, 2001). To enable them to work in tandem, swallowing, sucking, and esophageal motility are linked together within a control center originating in a central pattern generator in the brainstem (Jean, 2001). Swallowing in the infant is initiated when the milk bolus accumulates either in the space between the soft palate and the tongue or in the space between the soft palate and the epiglottis.

There are differences between an infant's and an adult's anatomy relative to the act of swallowing. In the infant, the hyoid and larynx are located higher in the neck and the pharynx is smaller. As the infant grows and matures, the hyoid and larynx migrate downward, the epiglottis and soft palate are no longer

FIGURE 3-6

Longitudinal Ultrasound Images of the Neck of a Breastfeeding Baby during Swallowing. The carotid vessels are situated anterior to the esophagus. The bolus of breast milk is outlined in the lower pharynx/esophagus. (A) No bolus is present. (B) The bolus expands the pharyngeal area as it moves inferiorly. (C) The bolus is narrowed as it passes into the upper esophageal region. (D) The bolus is almost cleared. Peristalsis is apparent on realtime imaging.



Source: Geddes, D. T., Chadwic,k L. M., Kent, J. C., Garbin, C. P., & Hartmann, P. E. (2010). Ultrasound imaging of infant swallowing during breastfeeding. *Dysphagia, 25,* 183–191.

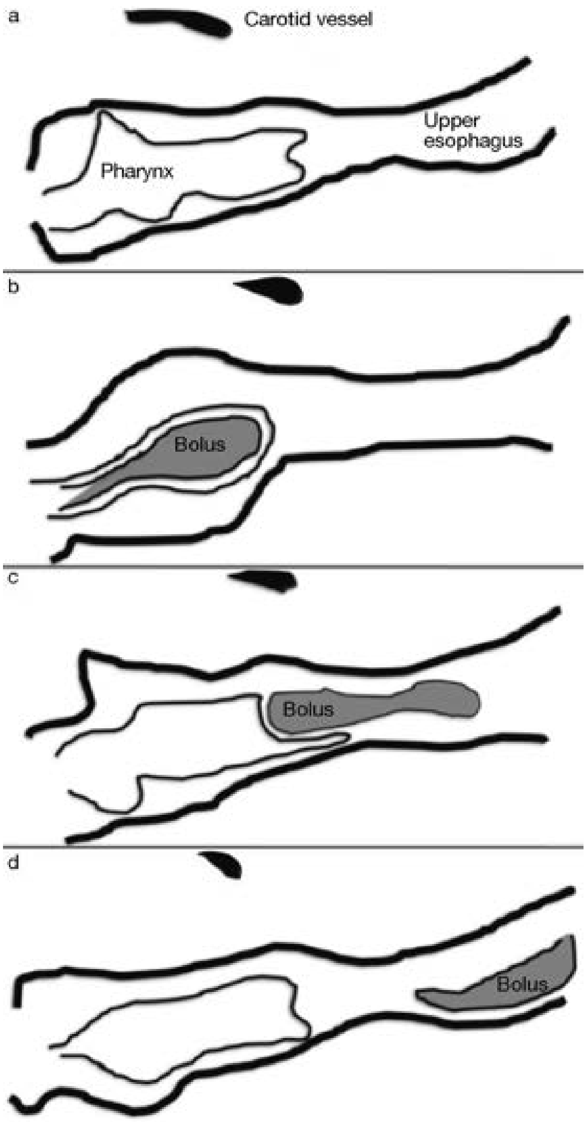
in direct approximation after 3 to 4 months of age, and more mature protection of the airway allows the infant to cease relying on specialized anatomic structures and configurations to support sucking, swallowing, and breathing.

Respiration ceases for a short period during swallowing. Geddes, Chadwick, Kent, Garbin, and Hartmann (2010a) found a significant correlation between swallow apnea and the movement of milk through the pharyngeal area, as detected by ultrasound.

Figures 3-6 and 3-7 show the progression of a milk bolus as it traverses the three phases of swallowing in a breastfed infant. The respiratory phase at which swallowing is timed differs between 2 weeks and 2 months of age and has been attributed to a critical window of neural development occurring during that time (Kelly, Huckabee, Jones, & Frampton, 2007). Swallowing in breastfed infants is typically followed by expiration. Mizuno, Ueda, and Takeuchi (2002) studied the effects of different fluids on the coordination between swallowing and breathing during bottle-feedings. When receiving breastmilk, compared with formula or distilled water in the bottle, the infants showed a significantly higher breathing rate. Swallows followed by inspiration were demonstrated less often with breastmilk in the bottle. The authors concluded that expressed breastmilk is more suitable for neonates because of the better coordination between swallowing and breathing, making subclinical aspiration less likely.

FIGURE 3-7

Schematic Diagrams of the Progression of the Milk Bolus in a Breastfed Infant. (A) No bolus is present. (B) The bolus expands the pharyngeal area as it moves inferiorly. (C) The bolus is narrowed as it passes into the upper esophageal region. (D) The bolus is almost cleared. Peristalsis is apparent on realtime imaging.



Source: Geddes, D. T., Chadwick, L. M., Kent, J. C., Garbin, C. P., & Hartmann, P. E. (2010). Ultrasound imaging of infant swallowing during breastfeeding. *Dysphagia, 25*, 183–191.

Swallowing can and should be assessed. Both the healthcare provider and the mother are encouraged to assess swallowing at each feeding in the early days to ensure milk transfer has occurred. Although an infant's jaw may move up and down, mimicking breastfeeding, jaw movement is not indicative of milk transfer. Signs of swallowing include the following:

- Deep jaw excursion (as opposed to shallow, biting, or chewing-like movements)
- Audible sound of swallowing
- Visualization of the throat during a swallow
- Vibration on the occipital region of the infant (a hand placed on the back of the baby's head may feel the swallow as a vibration)
- Movement of the throat felt by a finger over the trachea
- A small sound made by a puff of air from the nose
- A "ca" sound from the throat

Clinicians can assess swallow sounds by cervical auscultation with a stethoscope if they are uncertain that swallowing of milk is taking place.

- Placement of a small stethoscope adjacent to the lateral aspect of the larynx provides access to the sounds of the pharyngeal swallow (Vice, Heinz, Giuriati, Hood, & Bosma, 1990).
- In the absence of definitive evidence of swallowing, pre- and postfeed weights could be taken, if necessary, to validate whether milk transfer took place.

Breathing

Breathing must also be coordinated while feeding. The airway is protected during sucking and swallowing and must remain stable (resist collapse) during feeding, because sucking and swallowing occur in a rapid sequence. The patency of the airway can be affected by the sleep state, structural abnormalities, position of the neck, rate of milk flow, maturation (preterm vs. full term), illness, or central nervous system involvement. Increasing neck flexion causes the airway to become more prone to collapse; conversely, increasing neck extension helps increase the resistance to collapse. Some infants who suffer respiratory distress or who are premature may adopt an extended head and neck position because this posture makes it easier for them to breathe.

Breathing always takes precedence over feeding. Feeding difficulties can sometimes be an indicator of breathing problems, either from faulty positioning or an anatomic or physiological aberration in the infant. Positioning such infants at the breast may include subtle adjustments in the position of the head and proper shoulder girdle support to allow infants to remain well ventilated while they feed. Although infants prefer to breathe through their noses, they are not obligate nose breathers. Infants can breathe through their mouths for short periods of time, but it is accomplished at the expense of respiratory efficiency (Miller et al., 1985).

The bulk of research looking at suck, swallow, breathe synchrony has been conducted during bottle-feeding (Mathew, 1991a; Mathew & Bhatia, 1989; Meier, 1988, 1996). Repeated airway closure during swallowing has been shown to interrupt breathing. The more rapid milk flow from soft artificial nipples with large holes results in more frequent swallowing, less frequent opportunities for breathing, and significantly increased interruption in ventilation (Duara, 1989; Mathew, 1991b). These breathing alterations are more pronounced in preterm infants but also occur in full-term infants (Mathew, 1988; Mathew & Bhatia, 1989). Sucking during bottle-feeding interrupts breathing more frequently and for more sustained durations than sucking during breastfeeding (Meier, Lysakowski, Engstrom, Kavanaugh, & Mangurten, 1990). During bottle-feedings, infants alternate clusters of sucks and breaths. During breastfeeding, breathing is integrated into the sucking bursts. The suck–breathe pattern during breastfeeding suggests that infants may manipulate sucking parameters to control milk flow and accommodate breathing in such a way that apnea, bradycardia, and fatigue do not occur (Meier, 2001).

Differing bottle systems can affect oxygenation and how swallows are distributed during feedings. Goldfield, Richardson, Lee, and Margetts (2006) demonstrated that swallowing during breastfeeding was distributed nonrandomly and occurred at the peaks of intraoral sucking pressures. A group of infants in this study using a Playtex bottle system displayed a pattern of sucking, swallowing, and breathing that was more similar to the physiological norm of breastfeeding than the pattern observed in a group of infants using an Avent bottle system. If infants need to be supplemented and a bottle is chosen to provide extra milk, clinicians may wish to choose those bottles that disrupt breastfeeding the least (Peterson & Harmer, 2010).

Clinical Implications

Alterations in an infant's functional anatomy and physiology related to feeding may affect milk intake to a greater or lesser extent. During breastfeeding evaluations and especially if an infant presents with feeding problems, it is important to include an assessment of the infant's anatomic structures related to breastfeeding and their functioning.

Assessment of the Lips. The lips should present with the following characteristics:

- The lips should appear soft at rest, remain closed when awake and asleep, have a bow-shaped upper lip, and have a well-defined philtrum (the median groove between the upper lip and the nose).
- Both the upper and the lower lip should flange or flare outward when attached to the nipple/areola.
- The lips should be parted at a wide angle when measured from the corner of the mouth for proper latch. Aizawa et al. (2010) measured oral angles of breastfeeding and bottle-feeding infants, showing that the angle of the opened mouth of breastfed infants while nursing was approximately double that of infants sucking on standard artificial nipples. The angle at the corner of the mouth of infants feeding at the breast ranged from 112 degrees to 152 degrees, while infants sucking on a standard artificial nipple had an oral angle ranging from 55 degrees to 72 degrees.
- The lips should exert slight pressure to maintain a seal.

Alterations may include the following:

- Cleft lip: There is a great variation in cleft lip presentation, ranging from a small notch in the upper lip, either unilateral or bilateral, to a complete cleft through the lip into the nostril and through the upper alveolar ridge. A cleft in the lip compromises the seal needed to create negative pressure in the oral cavity. Many mothers fill the gap in the lip by manipulating the areola, their thumb, and the breast tissue to cover the defect. Infants with clefts of the lip are capable of generating suction, especially if the cleft is small (Reid, Reilly, & Kilpatrick, 2007). "Kissing" sounds heard during the feeding indicate that the anterior seal is being broken intermittently, which may compromise milk intake with each suck (Glass & Wolf, 1999).
- Loose, floppy, or asymmetrical lips: This problem can be associated with generalized hypotonia, partial paralysis or underdevelopment of the facial nerve (cranial nerve VII), facial asymmetry, and mouth droop or immobility. Any of these conditions may result in failure to form a seal for the oral cavity, causing periodic breaks in suction, inability to generate suction, smacking sounds, and/or milk leaking from the corners of the mouth. Asymmetrical lips may be seen if there is nerve damage or muscle weakness on either side of the face, causing one side of the mouth to droop and become slack on the weaker side.

- Retracted (forming a tight horizontal line over the mouth), pursed, or hypertonic lips: Increased tone may impair latch-on and active suckling, damage the nipple, and result in poor milk transfer. Pursed lips may result from feeding with artificial nipples that encourage mouth and lip closure. Lip retraction may also result from poor positioning where the neck or shoulder girdle is in extension.
- Tight (or short, inelastic) labial frenulum: This alteration may impede the flanging of the upper lip over the areola, as a restriction in the range of motion of the upper lip interferes with the upward and outward movement of the lip. An indication of a tight labial frenulum or "lip-tie" is an infant who purses the lips rather than flaring out the upper lip, resulting in a shallower, ineffective latch. This could result in nipple abrasion, painful or improper sucking, difficulty achieving a proper latch, or awkward positioning attempts by the infant (Wiessinger & Miller, 1995). Lip-tie may further contribute to reduced milk transfer, slow weight gain, fussiness from excessive air intake, colic-like symptoms, reflux, poor drainage in areas of the breast, reduced milk supply, and persistence of these problems after normal interventions have been tried. Kotlow (2004a; 2004b; 2011a) developed a classification of maxillary frenum attachments to aid in the clinical diagnosis of this condition (**Figure 3-8**). Class I is a normal attachment and requires no intervention. Class II attaches mostly into the gingival tissue. Class III attaches just in front of the anterior papilla, and class IV attaches into the papilla and extends into the hard palate. The papilla is the small bump of tissue just behind the area where the upper front teeth will erupt. Clinicians may wish to check for lip-tie when tongue-tie (ankyloglossia) is present and when normal interventions for common problems are ineffective. Lip-tie can be revised by clipping or by using a dental laser.
- Corresponding alterations in cheek functioning: Lips and cheeks work together. Deviations or alterations in function in one affect the efficiency and functioning in the other.

Assessment of the Cheeks. The cheeks should appear soft, be symmetrical, have well-defined sucking pads, and maintain good tone during sucking. Cheeks with low tone or that are unstable may be

FIGURE 3-8

Kotlow classification of infant maxillary frenum attachment

Class II
Attaches mostly into the gingival tissue

Class III
Attaches just in front of the anterior papilla*

Class IV
Attaches into the papilla* extending into the hard palate

*The papilla is the small bump of tissue just behind the area where the upper front teeth will erupt.

Source: Used with permission from Kotlow, L. (2010). Why can't my baby breastfeed: The effects of an abnormal maxillary frenum attachment. Retrieved from http://www.kiddsteeth.com/maxillaryfrenum_and_nursingfinal.pdf pulled inward during the generation of vacuum, appearing as dimpled cheeks. In addition, they may contribute to reduced suction overall. Damage to cranial nerves VII (facial) and V (trigeminal) (either prenatally or from mechanical forces during delivery) could produce weakness or low tone in the cheeks, rendering them less able to sustain sucking during feeding. A tongue that is retracted or that lodges behind the lower gum line during sucking also produces dimpled cheeks. Dimpled cheeks indicate incorrect latch and/or suckling. Preterm infants have diminished sucking pads, such that the buccal surfaces of the cheeks may not come in contact with the mother's nipple–areola. This contributes to reduced stability and weaker structural support during feedings. Clinicians can advise mothers to use the Dancer hand position, which allows the mother's fingers to compress the infant's cheeks, placing the inner cheeks in contact with the nipple/areola. Preterm infants may have difficulty both in opening their mouths wide enough and in closing their mouths over the areola.

Assessment of the Jaw. The lower jaw or mandible is typically in a neutral position at rest, with the lips touching. It moves in a smooth manner, correctly graded to engage in coordinated small excursions with a rhythmic quality. Several alterations in the structure of the jaw are possible.

- In a recessed or retracted jaw structure (not caused by muscle tension or the normal slight recess of the newborn's jaw), the lower gum ridge is posterior to the upper gum ridge. The tongue is usually of normal size but is positioned farther back in the mouth. In utero, micrognathia can interfere with the normal positioning of the tongue, contributing to lack of fusion of the palatal shelves, and potentially lead to a cleft palate. Because of its posterior positioning, the tongue may be unable to move forward enough to engage in normal movements. The infant may also have difficulty opening the mouth wide enough to latch to the breast. Micrognathia frequently appears as part of various syndromes such as the following:
  - Pierre Robin syndrome, which also includes a small tongue and usually a wide, U-shaped cleft palate. Infants have a great deal of difficulty breastfeeding, usually because of the cleft. They also need to be placed in a prone position for feeding due to the tendency of the tongue to fall back into the throat, obstructing the airway.
  - Hemifacial microsomia. In this condition, one side of the child's face is underdeveloped, affecting mainly the ear, mouth, and jaw. It is the second most common congenital facial anomaly after cleft lip/palate, occurring in 1 in every 3,000–5,600 live births. Involvement may range from mild, with just minor jaw asymmetry, to severe, with additional eye, vertebral, and cardiac involvement, which is known as Goldenhar syndrome. There may be unequal cheek fullness due to underdevelopment of the fat pad and muscles. If the central nervous system is affected, then there may be asymmetry in facial movements. Underdevelopment of the jaw necessitates careful and creative positioning and close monitoring of milk transfer and weight gain.
- Asymmetrical jaw or deviations to one side may be the result of asymmetrical muscle tone, a structural defect, positioning in utero, or torticollis. Torticollis may be caused by fibrosis (replacement with connective tissue) of the sternocleidomastoid (SCM) muscle, resulting in rotation of the head to the opposite side. The typical right-sided head position preference when supine, cranial flattening, and long periods in the supine position with the head turned to the right may contribute to a shortening of the SCM. Infants with localized head flattening (plagiocephaly) at birth have an increased risk for other deformational anomalies, such as mandibular hypoplasia (underdeveloped lower jaw) (Peitsch, Keefer, LaBrie, & Mulliken, 2002). Boere-Boonekamp and van der Linden-Kuiper (2001) examined 7,609 infants from a general population and found that 10% of infants less than 2 months of age had a preference for holding the head to one side and typically breastfed better on one side. The infant with torticollis has spent many weeks in utero with the head turned to one side while pushing on the opposite shoulder. Breastfed infants may have difficulty achieving a comfortable

breastfeeding position with the shortened SCM muscle (Stellwagen, Hubbard, & Vaux, 2004). Other physical features of infants with torticollis include misalignment of the eyes, asymmetry of the ears, upward tilting of the lower jaw and gum line, and limited neck movement. The mandible is tilted and not parallel with the upper jaw. Wall and Glass (2006) reported that mothers of infants with mandibular asymmetry may experience sore nipples, difficult latch, and reduced milk transfer. Chin support and use of a nipple shield may be helpful. The most expeditious intervention during the early days when an infant demonstrates torticollis/asymmetrical jaw is to position the infant at the breast with the head turned to the preferred side. Rather than switching positions to feed on the second breast, the infant is slid over in the same position to feed from the other breast. Stretching exercises may be prescribed or referral to an occupational or physical therapist may be necessary to improve the condition.

- Alterations in jaw functioning may show up as exaggerated jaw movements, jaw clenching, wide jaw excursions, clamping or biting down to achieve stability and hold onto the nipple, and low tone or poor control of the temporomandibular joint (TMJ). The TMJ may be affected by birth forces or instrument deliveries and may have an altered or limited range of movement. This joint moves in rather intricate ways: up and down like a hinge and gliding forward and down. A limited opening of the mouth caused by the inability of the TMJ to move in a full cycle of opening and closing may contribute to incremental latch-on in which an infant bites or nibbles his or her way onto the nipple rather than opening to a more optimal 160-degree angle. Wide jaw excursions beyond a 150- to 160-degree angle may be heard as smacking sounds as the tongue loses contact with the nipple–areola. Jaw instability is common in preterm infants and those with low orofacial tone, resulting in an unstable base for tongue movements. Sucking can be inefficient, and if the lips are unable to close, milk will leak from the corners of the mouth.

Assessment of the Tongue. The tongue should appear soft at rest, lying in the bottom of the mouth with a well-defined bowl shape. It should appear thin and flat, with a rounded tip and cupped sides. The tongue should neither protrude over the lips nor be seen when the mouth is closed. It should have sufficient tone and mobility to lift, extend, groove, and lateralize in a smooth and symmetrical manner. When a finger is placed in the infant's mouth, the tongue should cup around the finger, forming a distinct groove, and move in a rhythmic manner either in and out or up and down. Sucking pressure should be felt equally over the entire surface of the inserted finger. Besides playing a major role in sucking and swallowing, the tongue is an important oral structure that affects the shape of the palate, is involved in speech, contributes to the position of the teeth, and affects the development of the face.

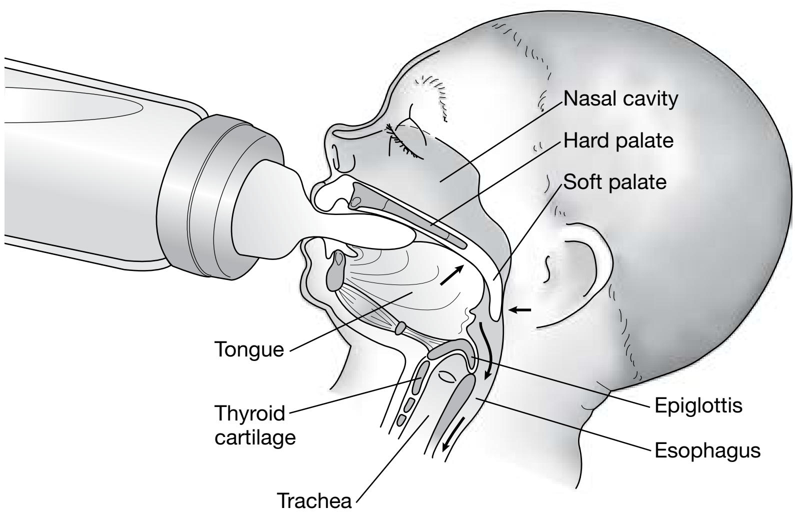
Alterations of the tongue may include the following conditions:

- In tongue-tip elevation, the tip of the tongue is in opposition to the upper gum ridge, making it difficult for an infant to latch to the breast.
- Bunched (compressed in a lateral direction), retracted, or humped (in an anterior–posterior direction) tongue may be part of an infant's high tone. The tongue is unable to form a central groove in any of these positions.
- A tongue with low tone may demonstrate little to no shape, may feel excessively soft, may protrude over the lower gum ridge, or may appear excessively wide or large for the mouth.
- Tongue thrust (an in-and-out pattern of movement with a strong protrusion or push out of the mouth) during active sucking may be associated with high tone and result in difficulty generating negative pressure.
- Tongue alterations may be a sign of oral defensiveness or, with tongue protrusion, may be a result of respiratory problems where the infant positions the tongue forward to increase respiratory capacity.

- Tongue movement anomalies may be seen in cesarean-born infants from traction forces placed on the cranial base during delivery. The hypoglossal canal, through which the hypoglossal nerve passes, can be disrupted as the head is lifted through the cesarean incision (Smith, 2004).
- The action of the tongue can be altered by the use of artificial nipples. Whereas the shape of the human nipple–areola conforms to the inner boundaries of the infant's mouth, the infant's tongue and oral cavity are obligated to conform to the parameters presented to them by the shape and rigidity of an artificial nipple. The artificial nipple positions the tongue behind the lower gum (**Figure 3-9**). If a breastfed infant were to do this at the breast, both the upper and lower gum would be in opposition to each other and the infant would actually bite the nipple. Such a scenario could result in extreme pain for the mother along with nipple damage and little milk transfer. High-flow artificial nipples may result in decreased oxygen levels due to rapid swallowing and limited intervals for breathing (**Figure 3-10A**). The artificial nipple (**Figure 3-10B**) does not fill the oral cavity, alters the labial seal, may obliterate the central grooving of the tongue, and may result in forces that impinge on the alveolar ridges and press them inward. Even so-called orthodontic improvements made to artificial nipples still force the normal shape and physiological action of the tongue to change (**Figure 3-10C**).
- Recent research on the sucking action of infants on artificial nipples has been conducted in an effort to manufacture artificial nipples that can claim to elicit similar sucking actions as on the breast. Segami, Mizuno, Taki, and Itabashi (2012) studied an experimental artificial nipple with a wide base, a firm shaft, and a valve at the base such that milk flowed only when the infant exerted vacuum. They concluded that there were no significant differences in perioral movements between breastfeeding

FIGURE 3-9

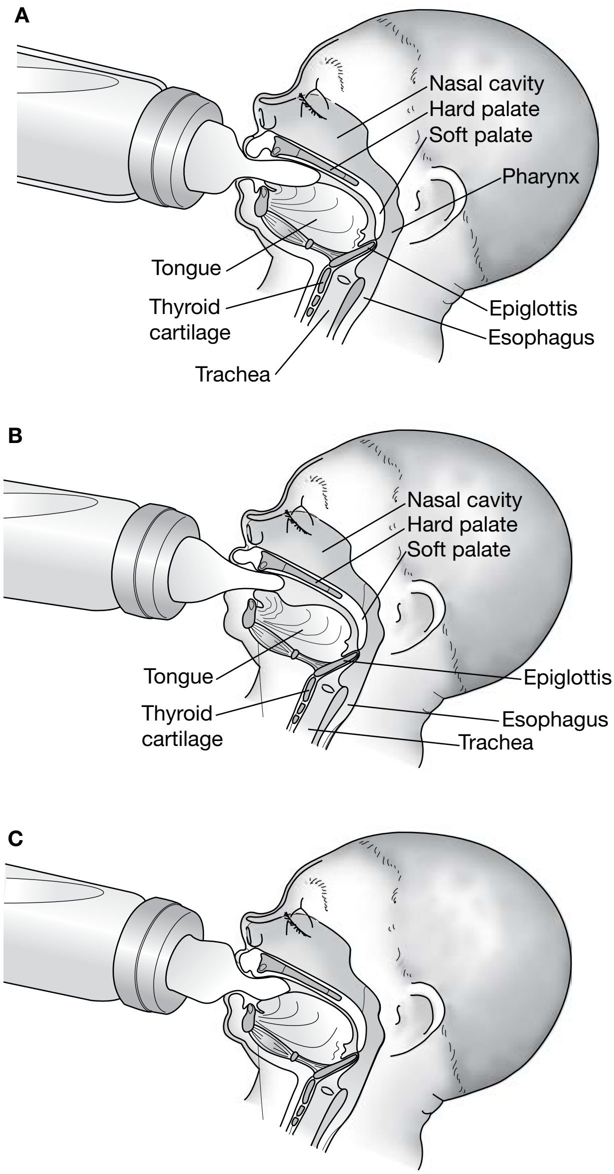
The Artificial Nipple Can Cause the Tongue to Remain Behind the Lower Gum



Source: Walker 2e

FIGURE 3-10

(A) Throat conformation for swallowing within the bottle suck cycle. (B) Traditional artificial nipple does not fill the oral cavity. (C) Altered "orthodontic" artificial nipple alters tongue position, compromising physiologic tongue action



Source: Walker 2e

and feeding on this experimental nipple. However, one important difference was noted: The vacuum generated during sucking on the experimental nipple was significantly smaller than that observed during feeding on the breast. This would be of concern if an infant transferred a lower vacuum to the breast and such a weaker sucking pressure was unable to transfer milk efficiently from the breast. The same observation of reduced vacuum application was seen in a study conducted by Geddes and colleagues (2012) on the development of a new artificial nipple that relies solely on vacuum to transfer milk from the bottle. Baseline (–12 mm Hg vs. –31 mm Hg) and peak vacuum (–67 mm Hg vs. –122 mm Hg) generation on the experimental artificial nipple was significantly lower than that applied at the breast. During the development of this same artificial nipple, Sakalidis and colleagues (2012b) again demonstrated that sucking pressures on the artificial nipple were lower than at the breast. Use of artificial nipples that lower vacuum generation could have negative implications when used by infants who already have a weak suck, reinforcing diminished vacuum application at the breast. Woolridge (2012) found that under ultrasound, peristaltic movements of the tongue could be visualized when infants were sucking on a different artificial nipple, with both vacuum and peristaltic tongue movements present during the same feeding.

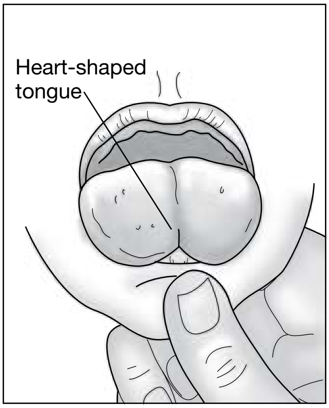
Tongue-tie, or ankyloglossia, is one of the most common tongue alterations and can affect infant milk intake and the integrity of the mother's nipples. The exact incidence of tongue-tie is unknown, but studies report a 4.2–4.8% incidence in general populations of newborns (Ballard, Auer, & Khoury, 2002; Messner, Lalakea, Aby, Macmahon, & Bair, 2000). Definitions and descriptions vary. Fernando (1998) described the condition based on both visual and functional aspects of the frenum: "Tongue-tie is a congenital condition, recognized by an unusually thickened, tightened, or shortened frenum [frenulum], which limits movement of the tongue in activities connected with feeding and which has an adverse impact on both dental health and speech." Hazelbaker (1993) defined tongue-tie as "impaired tongue function resulting from a tight and/or short lingual frenulum which may or may not involve fibers of the genioglossus muscle. Complete ankyloglossia can be defined as a 'fusing' of the tongue to the floor of the mouth."

Ankyloglossia limits the range of motion of the tongue and affects not only sucking but also speech, the position of the teeth, periodontal tissue (the tongue cannot clear residual fluid and food from the buccal cavities), jaw development, and swallowing. It has been associated with deviation of the epiglottis and larynx, harsh breath sounds, and mild oxygen desaturation during sucking (Mukai, Mukai, & Asaoka, 1991).

Tongue-tie is sometimes visualized during the newborn exam before hospital discharge. Mothers may complain of nipple pain and sore nipples, difficult latch, unsustained sucking, or the infant "popping" on and off the breast. Inability to transfer milk because of a mechanical difficulty can also lead to and present with insufficient milk, slow weight gain, engorgement, and plugged ducts. Observations of the breastfeeding may reveal milk leaking from the sides of the mouth, slow feeding, a clicking or smacking sound as the tongue loses contact with the nipple–areolar complex, sucking blisters on the infant's lips, and distorted appearance of the nipple when released from the infant's mouth. Tongue-tie has been described and assessed by the appearance of the tongue, the functioning of the tongue, or a combination of both parameters. The affected tongue has variously been described as heart shaped (**Figure 3-11**), notched, unable to protrude beyond the lower gum or elevate to the roof of the mouth, unable to cup and form a central groove, having a short and/or tight frenulum, having a thick or thin frenulum, having a frenulum attached anywhere along the underside of the tongue, and being anchored in various places, from the lower alveolar ridge or farther back along the floor of the mouth. A tight or short frenulum may be less than 1 cm in length and feel tight when a finger is placed under the midline of the tongue (Notestine, 1990). During a digital assessment of the tongue, it may be felt to snap back to the mandibular floor because it may be unable to elevate or maintain extension for very long (Marmet, Shell, & Marmet, 1990).

FIGURE 3-11

Heart-shaped Tongue



Source: Walker 2e

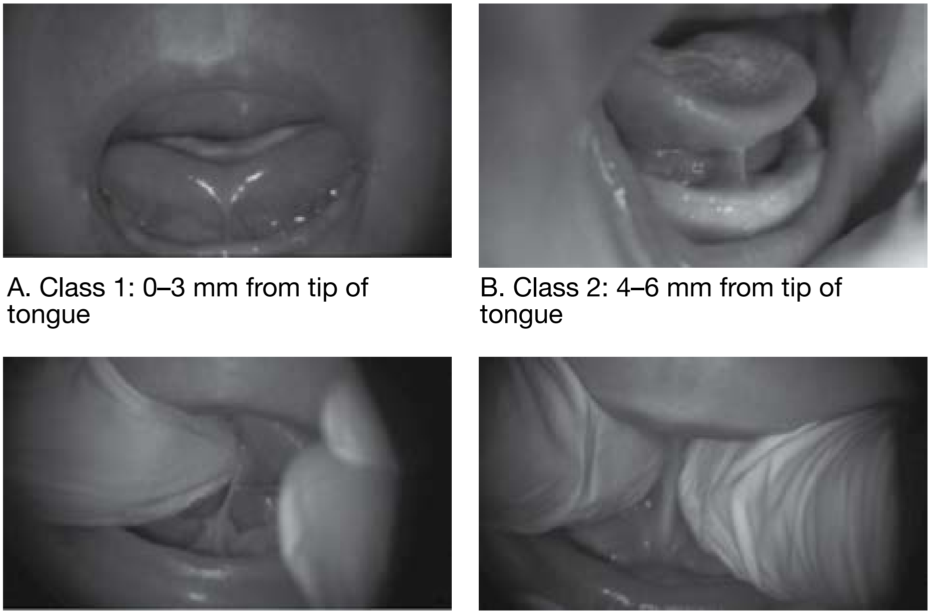
Consistent definitions and assessment tools are scarce. Kotlow (2004a) classifies tongue-ties based on the distance of the insertion of the lingual frenum to the tip of the tongue. A normal distance is 16 mm. Class IV is defined as a distance of 10–12 mm from the tip of the tongue; class III is a moderate tongue-tie, with a distance of 7–9 mm from the tip of the tongue; class II is severe, with a distance of 4–6 mm from the tip of the tongue; and class I is complete, with a distance of 0–3 mm from the tip of the tongue (**Figure 3-12**). If this distance is less than 8 mm, Kotlow (2004c) recommends that the frenum be revised.

Edmunds, Miles, and Fulbrook (2011) analyzed the evidence regarding tongue-tie to determine if tongue-tie could have a significant impact on breastfeeding and if frenotomy was a viable option. They found that for most infants, frenotomy offered the best chance of improved and continued breastfeeding and that the procedure did not lead to complications for the infant or the mother. Kumar and Kalke (2012) analyzed prospective cohort studies and randomized controlled trials regarding whether breastfeeding was adversely affected by tongue-tie and if frenotomy was helpful in rectifying the associated breastfeeding problems. They found a strong association between the presence of tongue-tie and breastfeeding problems in neonates. Their analysis revealed that neonates with tongue-tie are at increased risk for breastfeeding difficulties and that those with breastfeeding difficulties should be immediately referred to a lactation consultant with experience in handling this situation. They also stated that the presence of tongue-tie along with breastfeeding difficulties in an infant should constitute a valid indication for a referral for frenotomy. The data confirmed that frenotomy usually results in very rapid improvement in the symptoms associated with tongue-tie.

Some mothers present with excoriated nipples caused by the infant's tongue being unable to engage in the peristaltic anterior-to-posterior movement used to extract milk. The compression between the gums and the up-and-down movements of the tongue may result in abrasions on the upper aspect of the nipple as it rubs against the upper gum ridge or rugae of the hard palate or on the underside of the nipple as it experiences friction over the uncovered lower gum. If the frenulum is attached at the very tip of the tongue, the tongue can actually curl under. Tongue-tie restricts the tongue to a limited range of

FIGURE 3-12

Kotlow Classifications of Tongue Tie



A. Class 1: 0–3 mm from tip of tongue

B. Class 2: 4–6 mm from tip of tongue

C. Class 3: 7–9 mm from tip of tongue

D. Class 4: 10–12 mm from tip of tongue

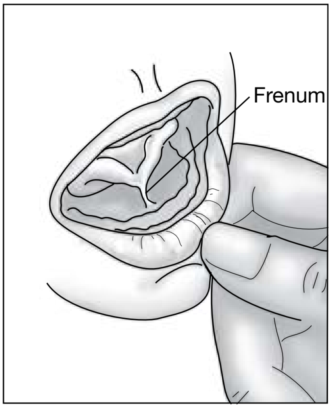
Source: Kotlow, L. (2011b). Infant reflux and aerophagia associated with the maxillary liptie and ankyloglossia (tonguetie). *Clinical Lactation, 2*, 25–29.

movements (**Figure 3-13**), making it problematic if the tongue tip remains unable to elevate as the jaw drops and/or interferes with the posterior tongue's movements in swallowing. Infants often engage in a number of compensatory movements to facilitate milk intake, such as reliance on negative pressure to obtain milk, fluttering action of the tongue as it seeks the nipple, chewing motions, biting actions to hold onto the nipple, and head movements to help with swallowing.

Tongue-tie is usually an isolated condition, but it can be seen as part of congenital syndromes. It is more common in boys than in girls, and is often familial. If the mother has a small breast, if the breast is highly elastic, and if the infant can draw in enough of the areola, breastfeeding may not become compromised. In a small study of five breastfed infants with tongue-tie, Geddes, Kent, and colleagues (2010b) found that in these mothers, nipple pain, milk intake by the infant, and milk production were not impacted by the tongue-tie. This finding suggests that some mothers may have certain breast, nipple, milk supply, or milk ejection characteristics that allow infants with tongue-tie to breastfeed successfully. However, failure to correct the tongue-tie at this stage may simply postpone the procedure until problems with eating, dentition, and speech require it at an older age.

FIGURE 3-13

Tight Frenum Causes Problems Elevating Tongue



Source: Walker 2e

Assessment of the Hard Palate. The hard palate should be intact, smoothly contoured, and appear as if the tongue would comfortably fit within its contours. Several alterations of the hard palate have been noted.

- Cleft lip and cleft palate constitute the fourth most common congenital disability, affecting 1 in 700 children in the United States. A cleft of the palate can include the hard and/or soft palate, with or without involvement of the lip; can be unilateral or bilateral; and may exhibit varying degrees of severity and involvement. Clefting may occur as an isolated event or may be part of a syndrome such as Pierre Robin syndrome or Turner syndrome. A submucous cleft of the hard palate can sometimes be felt as a notch or depression in the bony palate when palpated with a finger. Although tongue movements during sucking may be normal, compression can be generated only if there is adequate hard palate surface to compress against; sealing of the oral cavity is always compromised with both hard and soft palate clefts (Glass & Wolf, 1999). Feedings are long, and if signs of aspiration, such as frequent coughing, choking, sputtering, or color change, are observed, position changes may be required or assistive devices may be needed to ensure adequate intake (Edmondson & Reinhartsen, 1998). Usually, no airway obstruction or swallowing abnormalities are present, but with clefts of the palate, air is vented through the cleft, making it difficult to impossible to achieve vacuum, depending on how much of the palate is involved. Infants born with a cleft lip only usually have fewer problems breastfeeding than those with palatal defects.
- Breastfeeding infants with clefts (or supplying pumped breastmilk) provides the same disease protection as for any other infant. Indeed, breastmilk is especially important in reducing the otitis media that infants with cleft palate are so prone to develop. Breastfeeding encourages the proper use of the oral and facial musculature, promotes better speech development, and, when the infant is at breast, helps normalize maternal–infant interactions.
- Infants with cleft lip/palate are at an increased risk for insufficient milk intake. Weight gain, number of feedings, intake at each feeding, and diaper counts must be monitored to determine the need for supplemental breastmilk or other foods (Dowling, Danner, & Coffey, 1997).

- Poor feeding skills may sometimes be seen in newborns with cleft palate or cleft lip/cleft palate, and are even more commonly seen in infants with Pierre Robin syndrome, along with other syndromes. Many infants with isolated cleft lip and/or palate have normal feeding skills and experience problems only with vacuum generation, slow feedings, and nasal regurgitation. Actual oral motor dysfunction seen in infants with various syndromes can include minimal jaw excursions and absence of normal jaw and tongue movements for long periods. Reid, Kilpatrick, and Reilly (2007) found that babies with smaller clefts such as cleft lips and minor soft palate clefts were more likely to generate normal levels of suction on a bottle than infants with larger clefts, but not always for a long time. Infants with cleft lip and palate were also reported to have lower compression readings on the artificial nipple. This decreased compression could be due to the absence of palatal tissue against which to press the nipple or it could be a learned behavior from feeding with compressible bottles/nipples, which deliver milk regardless of whether suction or compression is generated.

  Masarei et al. (2007) looked at bottle sucking patterns of infants with unilateral cleft lip and palate and of infants with a cleft of the soft palate and at least two-thirds of the hard palate. They found two patterns of feeding—one in which the infants did not produce an identifiable sucking burst, but used a continuous disorganized pattern, and one in which the infants generated a short rhythmic sucking burst/pause pattern that was sustained for only 2 to 3 minutes followed by sucking disorganization. Sucking rates of these infants were more rapid than in infants with no cleft—109.26 sucks per minute in infants with clefts compared with 75.05 sucks per minute in infants without clefts. Infants with clefts generated compression or positive pressure for 71% of the feeding, while infants without clefts generated positive pressure for 26% of the feeding. Infants with clefts demonstrated an inconsistent range of tongue and jaw movements, arrhythmic tongue and jaw movements, and an altered rate of sucking. Many of these sucking alterations appear to be attempts by the infants to compensate for the anatomic abnormalities. Lacking enough vacuum for milk removal, infants compensated with faster and more compressions or positive pressure generation to remove milk by using a mechanical ability that they possessed. While this study looked at feeding patterns on a bottle, it is likely that infants with cleft defects will also attempt to compensate in a similar manner at the breast. Clinicians might wish to visualize the entire mouth (including the hard and soft palate) of an infant who is demonstrating the feeding patterns just described. Feeding inefficiency is predictive of poor feeding in young infants. Neonates transferring less than 2.2 mL/minute of milk and infants transferring less than 3.3 mL/minute of milk are highly predictive of poor feeding skills (Reid et al., 2006).
- If the infant is unable to withdraw sufficient milk from the breast, expressed breastmilk can be provided through a supplemental tube feeding device at breast or through a special bottle-feeder. Mothers will need an electric breast pump and a pumping plan to provide breastmilk and maintain an adequate supply. They may use alternate massage when the infant is at breast or hand express milk directly into the infant's mouth, but the infant may be unable to adequately drain the mother's breasts, increasing the risk of insufficient milk supply, engorgement, plugged ducts, and mastitis unless the breasts are more thoroughly drained at each feeding (Biancuzzo, 1998).
- Some infants may be fitted with a palatal obturator (a prosthesis molded to fill the cleft and provide an "artificial" palate). This device is designed to provide a solid surface against which to compress the nipple and seal the oral cavity to facilitate achieving negative pressure for milk withdrawal. It may also help to decrease the amount of time it takes for each feeding, reducing the fatigue for both infant and parents.
- Managing the infant with a cleft defect is typically accomplished by a team of healthcare professionals, with surgeries, treatment, and therapy that can continue for many years. Because most orofacial clefts are immediately apparent after birth, it is important that healthcare providers experienced with feeding cleft-involved infants be readily available to parents. Parents are especially concerned about feeding issues, and nurses caring for mothers of newborns with orofacial clefts should quickly

refer mothers to lactation specialists/consultants experienced with the associated feeding complications (Byrnes, Berk, Cooper, & Marazita, 2003).

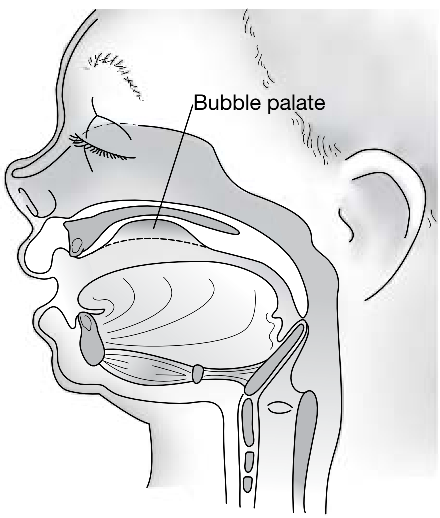
- Other palatal variations such as a bubble palate (**Figure 3-14**) may also impede breastfeeding. A bubble palate is defined as a "concavity in the hard palate, usually about 3/8 to 3/4 in (1–2 cm) in diameter and 1/4 in (1/2 cm) deep" (Marmet & Shell, 1993). Because of the position of the mother's nipple relative to the bubble, the nipples can become abraded, inflamed, and sore if the nipple rubs against the anterior ridge of the bubble. Weight gain problems may also ensue if the infant is unable to transfer sufficient milk (Snyder, 1997).

Assessment of the Soft Palate. The soft palate generally has thinner mucosa than the hard palate and may be somewhat darker in color. It is firm but spongy, the uvula should be in the midline and intact, and the soft palate should not sag to either side. The following notes relate to alterations of the soft palate:

- Cleft of the soft palate and uvula is always midline. Submucous clefts are a subgroup of clefts with intact mucosa lining the roof of the mouth that can make it difficult to see when looking into the mouth. The underlying muscle and bone are at least partially divided, indicating insufficient median fusion of the muscles of the soft palate. A submucous cleft may be identified by the presence of a bifid uvula, a very thin translucent strip of mucosa in the middle of the roof of the mouth, and a notch at the back edge of the hard palate that can be felt with the fingertip. Reiter and colleagues (2012) found a potential role of maternal smoking during pregnancy in the formation of a submucous cleft palate, especially if the infants had particular genetic variants that predisposed for orofacial clefts. Infants may experience swallowing difficulties and persistent middle-ear disease. Damage to the glossopharyngeal nerve (cranial nerve IX) and the vagus nerve (cranial nerve X) may cause a paralysis of the

FIGURE 3-14

Bubble Palate



Source: Walker 2e

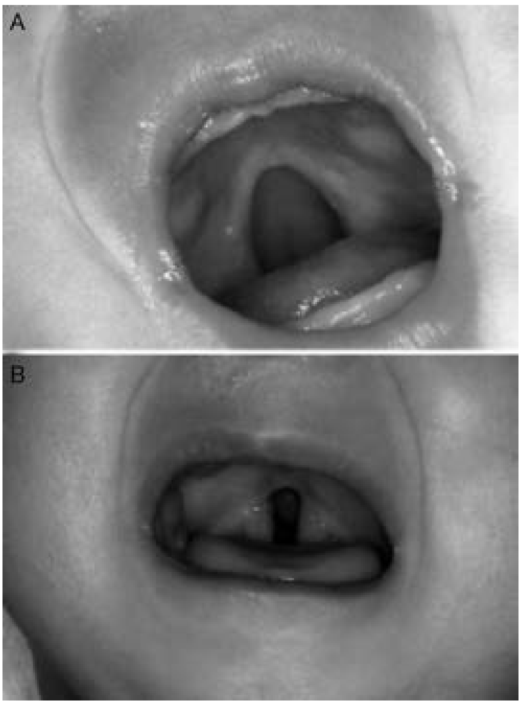
soft palates, which will sag on the affected side. Babies with this type of cleft suck rhythmically but generate only weak suction and may feed for prolonged periods but transfer little milk, resulting in inadequate weight gain. They may have nasal snorting, frequent sneezing, or regurgitation through the nares. Clefts of the soft palate will not be detected on digital exam. The examiner needs to visualize the soft palate by using a light and a tongue depressor on the posterior tongue.

- A congenital short palate can result in velopharyngeal insufficiency, as can insufficient tissue repair of a cleft palate (Morris & Klein, 2000).
- The soft palate is typically involved when the hard palate has a cleft. This can result in an open nasopharynx during swallowing and reflux of milk into the nasal cavity, swallowing of air into the stomach, and, if ear tubes are present, milk sometimes leaking through the tubes and out the ear.

Not all clefts are identified at birth or on day 1, with delayed detection of clefts experienced by some families. Habel, Elhadi, Sommerlad, and Powell (2006) found that isolated cleft palates that were U shaped were more often detected on day 1 than were narrow V-shaped clefts (**Figure 3-15**). A delay in detection is

FIGURE 3-15

Clefting that Might be Missed without Direct Visualization of the Palates. (A) Broad U-shaped cleft palate extending one-third way into the hard palate. (B) Narrow V-shaped cleft palate at the junction of the soft and hard palates



Source: Habel, A., Elhadi, N., Sommerlad, S., & Powell, J. (2006). Delayed detection of cleft palate: An audit of newborn examination. *Archives of Disease in Childhood, 91,* 238–240.

more likely in the case of small narrow clefts in the soft palate. Digital examination of the infant's mouth can miss small clefts, and in the presence of symptoms (e.g., feeding difficulties, nasal regurgitation), a visual examination of the mouth should be performed. The tongue needs to be sufficiently depressed to visualize the back of the mouth with a flashlight.

Assessment of the Nasal Cavity, Pharynx, Larynx, and Trachea. These structures can be assessed with varying tests and instruments when significant deviations from normal are suspected. Alterations in swallowing and breathing or problems with the coordination of suck, swallow, breathe may alert the clinician to an anatomic or structural defect, such as the following:

- Choanal atresia—occlusion of the passage between the nose and pharynx by a bony or membranous structure.
- Vocal cord anomalies or paralysis.
- Edema from trauma such as intubation, extubation, or suctioning.
- Structural narrowing such as subglottic stenosis.
- Instability of a structure, such as tracheomalacia (softening of the tracheal cartilage) or laryngomalacia (softening of the tissues of the larynx, typically when the epiglottis bends over and partially obstructs the opening to the larynx). Infants with tracheomalacia, laryngomalacia, and laryngotracheomalacia also have a higher incidence of gastroesophageal reflux (Bibi et al., 2001).
- Spasms of a structure, such as laryngospasm.

Because these structures are not readily visible, the clinical presentation, feeding and health history, and behavioral observation of a feeding are necessary to gather data for a feeding plan and/or referral. Infants may present with one or a combination of signs and symptoms. The underlying cause of the problems may be unclear because similar signs and symptoms may reflect different etiologies. Complex medical diseases and conditions (e.g., bronchopulmonary dysplasia, cardiac problems, cerebral palsy, genetic syndromes) may also produce some of the following signs and symptoms even if they are not related to structural or anatomic defects. Infants presenting with these symptoms should be checked by their primary care provider and may be referred to a specialist or undergo testing (Arvedson & Lefton-Greif, 1998) to determine the primary problem:

- Noisy breathing
- Chronic congestion
- Inadequate weight gain
- Refusal to feed
- Apnea/bradycardia
- Coughing, choking, or gagging during a feeding
- Cyanosis, pallor, or sweating
- Wheezing, stridor, or suprasternal retractions
- Excessive drooling

Depending on the type and extent of interference with feeding at the breast, modifications may be warranted in such elements as total body positioning, flexion or extension of the head, use of a nipple shield, expression of milk, and use of alternate feeding devices.

Assessment of the Esophagus. The most common disorder related to the esophagus in an infant is gastroesophageal reflux (GER), although other esophageal disorders can interfere with swallowing (e.g., upper or lower esophageal sphincter dysfunction, esophageal dysmotility, extrinsic compression, or mechanical obstruction) (Arvedson & Lefton-Greif, 1998). GER entails the passive backflow of stomach contents into the esophagus and implies a functional or physiological process in a healthy infant with no underlying systematic abnormalities. This disorder is associated with a transient relaxation of the lower esophageal sphincter due to fundal stimulation, which allows gastric contents to wash back into the lower esophagus and often be regurgitated. GER (spitting up) generally peaks between 1 and 4 months of age and is seen in 40–65% of healthy infants. The supine position and the slumped seated position can exacerbate reflux during the times that the lower esophageal sphincter relaxes (Jung, 2001). Some infants with frequent GER have an inflamed throat and a hoarse cry. Infants may arch their neck and back when feeding, may gag or cough, and engage in chewing motions (rumination or "cud chewing"). Infants with an unexplained chronic cough should be evaluated for GER (Borrelli et al., 2011). Jadcherla and colleagues (2012) looked at how GER might be influenced by certain feeding mechanics and found that at least in preterm infants, feeding duration and feeding flow rate modifications could significantly reduce GER events. In bottle- and gavage-fed infants, slowing down the feeding and decreasing the milk flow rate significantly reduced the total number of GER events. The authors speculated that a large volume of swallowed milk and air over a short period of time could contribute to the gastric distention and fundal stimulation that precipitate GER events. Applying this finding to the breastfeeding situation might suggest that in infants with GER, mothers might wish to elicit the milk ejection reflex before putting the baby to breast to reduce the volume and speed of milk intake. Mothers might also consider extending the feeding time by allowing some periods of rest to prolong the feeding.

Gastroesophageal reflux disease (GERD) is a pathological process characterized by clinical features such as regurgitation with poor weight gain, irritability, pain in the lower chest, possible apnea and cyanosis, wheezing, laryngospasm, and possibly aspiration, chronic cough, and stridor. An infant with GERD may have more than five episodes of reflux per day, regurgitate approximately 28 g per episode, and refuse or show irritability during feedings (Arguin & Swartz, 2004). Some infants with GERD do not respond to medication. In infants with more severe GERD, an abnormal hyperextension of the neck with torticollis (Sandifer syndrome) may be seen.

Infants with GER or GERD may demonstrate feeding resistance, arching at the breast, limited feeding time at the breast, and discomfort when fed in the cradle position. These infants feed better when breastfed in an elevated position of 45 degrees or more (Boekel, 2000; Wolf & Glass, 1992). After each feeding, infants should be kept upright, as in a front pack carrier or wrap, rather than slumped down in an infant seat or immediately put in a supine position. Care must be taken when using a sling so as not to increase intra-abdominal pressure.

Kotlow (2011b) describes tongue-tie and maxillary lip-tie as potential contributors to symptoms typically associated with reflux and colic. The association is the large amount of air that can be swallowed and the inability of the lips to form a complete seal on the breast. Once a maxillary lip-tie and/or a tongue-tie is released, the lips can form a more complete seal and the tongue remains in contact with the nipple/areola, reducing the intake of air. Alcantara and Anderson (2008) report that chiropractic and cranial-sacral therapy may provide relief for some infants suffering from GER.

PUTTING IT ALL TOGETHER

The infant's feeding anatomy and associated physiology come together at feeding times in a complex series of actions that must occur in synchrony to ensure transfer of sufficient milk from the mother's breast into the infant. Guidelines for assessing the breastfeeding mother and infant have emphasized the importance of the visual assessment conducted in a coordinated manner (Walker, 1989). Assessment is the foundation of professional practice. Breastfeeding assessment is part of the community standard of care for hospital maternity units. The Committee on Fetus and Newborn of the American Academy of

Pediatrics (2004) recommends that a number of criteria be met before any newborn discharge, including two items specific to breastfeeding:

1. The infant has completed at least two successful feedings, with documentation that the infant is able to coordinate sucking, swallowing, and breathing while feeding.
2. The mother's knowledge, ability, and confidence to provide adequate care for her baby are documented by the fact that she has received training and demonstrated competency regarding breastfeeding or bottle-feeding. The breastfeeding mother and baby should be assessed by trained staff regarding breastfeeding position, latch-on, and adequacy of swallowing.

TOOLS

Tools have been developed to predict future problems or to help identify mothers who are at risk for early weaning. Assessing breastfeeding activities using a systematic approach can be undertaken in a number of ways. Some clinicians use (or adapt) one of a number of short clinical assessment tools that have been developed for the following purposes:

- Organize the breastfeeding assessment
- Identify both normal and abnormal patterns at the breast
- Determine whether milk transfer has occurred
- Document and chart breastfeeding behaviors
- Direct professional intervention and patient education to areas where it is needed
- Serve as a communication vehicle among professional caregivers
- Establish evaluation and teaching standards
- Reduce inappropriate supplementation
- Predict which infants are at risk for early weaning
- Recognize mother–baby pairs in need of referrals and follow-up

Using a clinical assessment tool helps objectively document feedings and may be expedient in the hospital or clinic setting. Some of the tools assign a score with cut-off points that serve as a basis for making referrals. Several have been shown to be predictive of risk for early weaning and are also used to justify the need for more intensive breastfeeding assistance. Not all tools have been shown to be valid (i.e., the tool measures what it states it measures) and/or clinically reliable (i.e., it consistently measures the intended behavior). However, the tools that assess feedings at the breast depend on the clinician's observation of a feeding and do not rely on subjective descriptions of "good, fair, poor" or number of minutes at each breast, descriptions that are inappropriate, inaccurate, and of little clinical relevance.

Infant Breastfeeding Assessment Tool

Matthews (1988) noted that Infant Breastfeeding Assessment Tool (IBFAT) scores (**Table 3-3**) were not predictive of abandonment of breastfeeding but rather illustrated that sucking behaviors improved over time. There was a significant difference in breastfeeding competence between infants of first-time mothers, who took a mean of 35 hours to establish effective breastfeeding, compared with infants of multiparous mothers, who took a mean of 21.2 hours to establish effective breastfeeding. A longer period to establish effective breastfeeding was also associated with the timing of drug administration in labor, as 83.4% of primiparous mothers received alphaprodine (Nisentil) within 1–4 hours before delivery compared with 45% of multiparous mothers.

TABLE 3-3

Infant Breastfeeding Assessment Tool

Component	*3*	*2*	*1*	*0*
Readiness to feed	Started to feed readily without effort	Needed mild stimulation to start feeding	Needed vigorous stimulation to feed	Cannot be roused
Rooting	Rooted effectively at once	Needed coaxing to root	Rooted poorly, even with coaxing	Did not try to root
Fixing (latch-on)	Started to feed at once	Took 3–10 minutes to start feeding	Took > 10 minutes to start feeding	Did not feed
Sucking pattern	Sucked well on one or both breasts	Sucked off and on, but needed encouragement	Some sucking efforts for short periods	Did not suck

Maximum score: 12
Score of 10–12 = effective vigorous feeding
Score of 7–9 = moderately effective feeders
Score 0–6 = effective sucking rhythm not established

Source: Adapted from Matthews, M. K. (1988). Developing an instrument to assess infant breastfeeding behaviour in the early neonatal period. *Midwifery, 4*, 154–165.

The IBFAT does not assess swallowing, which can be a drawback in its use unless swallowing is included in the "sucking pattern" measurement score. Matthews (1991) also observed that mothers can use the IBFAT to assess their infants' feeding progress, with infants who score the highest having mothers who are more pleased with the feeding. Primiparous mothers had a significantly higher percentage of feedings at which they were dissatisfied, with low scores tending to occur predominantly during the first 48 hours after birth. Mothers' satisfaction or positive feedback is important in the maternal decision to continue breastfeeding and persevere during breastfeeding difficulties. Mothers who experience dissatisfaction during the early time after birth will need more intensive support to curtail the negative feedback generated when an infant struggles to breastfeed. An infant who does not achieve a score in the 10 to 12 range of the IBFAT upon discharge from the hospital should be referred for follow-up (Matthews, 1993).

Latch Assessment Documentation Tool

This latch assessment tool (**Table 3-4**) was developed to serve as a quick and easy method for documenting a mother's ability to attach her baby properly to the breast and to observe the infant's sucking. Each component was defined and a plus or minus used to indicate whether the behavior was present or absent, respectively. If any component of the latch assessment is charted as insufficient, the nurse writes a progress note to detail the deviation or variance as well as to chart what corrective action was taken. Use of this form served to visually remind nurses to follow up with mothers who needed assistance to latch their infants successfully (Jenks, 1991). Swallowing was not evaluated as a separate component but was mentioned as part of the adequate suction measurement (e.g., "suck/swallow ratio is 1–2/second"). No numerical score is assigned to the feeding effort; however, this tool is designed to identify breastfeeding problems so that a plan of care can be initiated as early as possible.

TABLE 3-4

Latch Assessment Documentation Tool

Parameter	***Code*** ***+ (Normal and Sufficient)*** ***– (Insufficient)***
Baby's gum line placed over mother's lactiferous sinuses	
Both lips are flanged	
Complete jawbone movement	
Tongue is positioned under the areola	
Adequate suction	

Source: Adapted from Jenks, M. (1991). Latch assessment documentation in the hospital. *Journal of Human Lactation, 7*, 19–20.

Breastfeeding Assessment Tool

Inaccurate, inadequate, or subjective/qualitative descriptions of breastfeeding in the hospital perpetuate inconsistencies in care and sometimes the communication of useless information. In an effort to improve breastfeeding assessment, the Breastfeeding Assessment Tool was developed to improve documentation of objective observations of breastfeeding status (Bono, 1992). Although nurses resisted filling out another form, practices supportive of breastfeeding increased with the improved awareness of the necessity of such documentation. Tools such as the Breastfeeding Assessment Tool, which includes audible swallowing as a component to be assessed, help prevent hospital staff from minimizing the importance of ongoing assessment of the breastfeeding couple.

Systematic Assessment of the Infant at Breast (SAIB)

It is recommended that each component of the SAIB (**Table 3-5**) be evaluated as part of an initial breastfeeding assessment and completed at least once before the mother and baby are discharged home. The SAIB delineates the essential components of a breastfeeding episode that are central to effective breastfeeding and milk transfer. It emphasizes the importance of assessing for and documenting that swallowing has occurred. Without an assessment of swallowing, it cannot be assumed that the infant has received any milk. A continuing pattern of no audible swallowing signals the need for careful investigation into the cause (Shrago & Bocar, 1990).

Mother–Baby Assessment (MBA) Tool

The MBA tool (**Table 3-6**) focuses on the mother's and baby's efforts in learning to breastfeed and tracks the progress of both partners (Mulford, 1992). The total number of pluses yields a numerical score that indicates the effectiveness of the breastfeeding session:

- A score of 3 or lower indicates that one partner (mother or baby) tried to initiate breastfeeding but the other was not ready.
- A score of 4 or 5 indicates that the infant was put to the breast but did not latch.

TABLE 3-5

Systematic Assessment of the Infant at Breast

Alignment

- Infant is in flexed position, relaxed with no muscular rigidity.
- Infant's head and body are at breast level.
- Infant's head is aligned with trunk and is not turned laterally, hyperextended, or hyperflexed.
- Correct alignment of infant's body is confirmed by an imaginary line from ear to shoulder to iliac crest.
- Mother's breast is supported with cupped hand during first 2 weeks of breastfeeding.

Areolar Grasp

- Mouth is open widely; lips are not pursed.
- Lips are visible and flanged outward.
- Complete seal and strong vacuum are formed by infant's mouth.
- Approximately ½ inch of areolar tissue behind the nipple is centered in the infant's mouth.
- Tongue covers lower alveolar ridge.
- Tongue is troughed (curved) around and below areola.
- No clicking or smacking sounds are heard during sucking.
- No drawing in (dimpling) of cheek pad is observed during sucking.

Areolar Compression

- Mandible moves in a rhythmic motion.
- If indicated, a digital suck assessment reveals a wavelike motion of the tongue from the anterior mouth toward the oropharynx (a digital suck assessment is not routinely performed).

Audible Swallowing

- Quiet sound of swallowing is heard.
- Sound may be preceded by several sucking motions.
- Sound may increase in frequency and consistency after milk ejection reflex occurs.

Source: Adapted from Shrago, L., & Bocar, D. The infant's contribution to breastfeeding. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 19,* 209–215.

- A score of 6 indicates possible milk transfer.
- A score of 7 or 8 gives clearer evidence of milk transfer.
- A score of 9 or 10 scored consistently over a number of feedings indicates the need for only minimal follow-up.

The higher the MBA score, the more effective the breastfeeding episode. A low score indicates the need for assistance from a skilled lactation specialist or consultant.

Via Christi Breastfeeding Assessment Tool

The Via Christi Breastfeeding Assessment Tool (Riordan & Riordan, 2000) (**Table 3-7**) assigns a score of 0, 1, or 2 to five factors. Scores range from 0 to 10.

TABLE 3-6

Mother–Baby Assessment Tool

Steps/Points	*What to Look For/Criteria*
#1 Signaling:	
1	Mother watches and listens for baby's cues. She may hold, stroke, rock, talk to baby. She stimulates baby if he is sleepy, calms baby if he is fussy.
1	Baby gives readiness cues: stirring, alertness, rooting, sucking, hand-to-mouth, vocal cues, cry.
#2 Positioning:	
1	Mother holds baby in good alignment within latch-on range of the nipple. Baby's body is slightly flexed, entire ventral surface facing mother's body. Baby's head and shoulders are supported.
1	Baby roots well at breast, opens mouth wide, tongue cupped and covering lower gum.
#3 Mixing:	
1	Mother holds her breast to assist baby as needed, brings baby in close when his mouth is wide open. She may express drops of milk.
1	Baby latches on, takes all of nipple and about 2 cm (1 inch) of areola into mouth, then suckles, demonstrating a recurrent burst-pause sucking pattern.
#4 Milk transfer:	
1	Mother reports feeling any of the following: thirst, uterine cramps, increased lochia, breast ache or tingling, relaxation, sleepiness. Milk leaks from opposite breast.
1	Baby swallows audibly; milk is observed in baby's mouth; baby may spit up milk when burping. Rapid "call-up sucking" rate (two sucks/second) changes to "nutritive sucking" rate of about 1 suck/second.
#5 Ending:	
1	Mother's breasts are comfortable; she lets baby suckle until he is finished. After nursing, her breasts feel softer; she has no lumps, engorgement, or nipple soreness.
1	Baby releases breast spontaneously, appears satiated. Baby does not root when stimulated. Baby's face, arms, and hands are relaxed; baby may fall asleep.

The MBA is an assessment method for rating the progress of a mother and baby who are learning to breastfeed. For every step, both mother and baby should receive a + before either one can be scored on the following step. If the observer does not observe any of the designated indicators, score 0 for that person on that step. If help is needed at any step for either the mother or the baby, check "Help" for that step. This notation will not change the total score for mothers and babies.

Source: Adapted from Mulford, C. (1992). The mother-baby assessment (MBA): An "Apgar score" for breastfeeding. *Journal of Human Lactation, 8,* 79–82.

- Immediate high risk: All mothers who have had breast surgery; all infants who have lost more than 10% of their birth weight
- 0 to 2 = High risk: Close, immediate postdischarge follow-up needed; phone call and visit to healthcare provider within 24 hours
- 3 to 6 = Medium risk: Postdischarge phone call within 2 days; visit to healthcare provider within 3 days
- 7 to 10 = Low risk: Information given to mother and routine phone call

TABLE 3-7

Via Christi Breastfeeding Assessment Tool

Assessment Factors	*0 Points*	*1 Point*	*2 Points*	*Score*
Latch-on	No latch-on achieved	Latch-on after repeated attempts	Eagerly grasped breast to latch on	
Length of time before latch-on and suckle	Over 10 minutes	4–6 minutes	0–3 minutes	
Suckling	Did not suckle	Suckled but needed encouragement	Suckled rhythmically and lips flanged	
Audible swallowing	None	Only if stimulated	Under 48 hours, intermittent; over 48 hours, frequent	
Mom's evaluation	Not pleased	Somewhat pleased	Pleased	
Total Score:				

Source: Adapted from Riordan, J. (1999). Via Christi breastfeeding assessment tool. Unpublished.

This tool was developed as an expedient way to assess excessively sleepy infants whose mothers received high does of labor analgesia and are at risk for breastfeeding problems. This research-based assessment tool scores early breastfeedings to establish a risk category for assigning appropriate follow-up.

Latch-on Assessment Tool

The Lactation Assessment Tool (**Table 3-8**) is a guided assessment form emphasizing comprehensive assessment from prefeeding behaviors through latch-on and during the actual feeding process. When used to study the elements of the feeding process that are thought to be related to nipple pain and damage, positioning errors were found to be related to pain, but no one element was shown to be the sole cause of sore nipples. Rather, many aspects of the breastfeeding episode, especially the latching process, contribute in elevating or reducing the mother's level of pain (Blair, Cadwell, Turner-Maffei, & Brimdyr, 2003).

LATCH Scoring System

Mothers who use the LATCH criteria after discharge have reported increased confidence in the assessment of their infants' breastfeeding and knowledge about when to seek help for breastfeeding problems (Hamelin & McLennan, 2000). Audible swallowing is an integral part of this tool, which evaluates the amount of help a mother needs to physically breastfeed. A composite score ranging from 0 to 10 is possible in the LATCH scoring system (**Table 3-9**), facilitating the identification of needed interventions and improving charting (Jensen, Wallace, & Kelsay, 1994). Breastfeeding behavioral changes can be followed over time, and the tool can also be used by mothers as a means of continuing assessment.

Breastfeeding Assessment Score

The Breastfeeding Assessment Score (**Table 3-10**) is designed to be administered before hospital discharge to identify infants at risk for breastfeeding cessation in the first 7–10 days of life (Hall et al., 2002). Hall et al. (2002) demonstrated that approximately 10.5% of mothers from the study sample of 1,075 women had completely weaned by 7–10 days postpartum. Scoring with the tool ranges from 0 to 2, representing

TABLE 3-8

Latch-on Assessment Tool/Lactation Assessment Tool

The Latching Process

- Rooting
- Gape
- Suck
- Seal

Angle of Infant's Mouth Opening

- 160 degrees
- 100 degrees
- 90 degrees
- 60 degrees

Infant's Lip Position

- Top and bottom lips flanged
- Top lip turned in
- Bottom lip turned in
- Top and bottom lips turned in

Infant's Head Position

- Nose and chin
- Chin away
- Nose away
- Chin and nose away

Infant's Cheek Line

- Smooth
- Broken
- Dimpled

Height at the Breast

- Nose opposite nipple
- Too high
- Too low

Body Rotation

- Chest to mother's breast
- Head only turned to breast

Body Relationship

- Horizontal
- Angle

Breastfeeding Dynamic

- Bursts 2:1 or 1:1
- Occasional 8+:1
- Sucks, no swallows

Rhythm of Mother's Breast While Breastfeeding

- Breast moves rhythmically
- Breast stays stationary

Source: Adapted from Healthy Children Project 2000. (2000). *Latch-on Assessment Tool (LAT)*. East Sandwich, MA: Healthy Children Project.

low, moderate, or high risk of early weaning. The highest overall score is 10, with 2 points being subtracted for each of the three variables of previous breast surgery, maternal hypertension, and vacuum extraction at delivery, creating a score range of –6 to +10. Results from the study were as follows:

Score	No. of Mothers	Cessation Rate at 7–10 Days Postpartum
≥ 8	705 of 1,075	5% (37 of 705)
< 8	370 of 1,075	21% (77 of 370)

The Breastfeeding Assessment Score identifies those mothers most in need of additional follow-up. The 370 women scoring lower than 8 on this screening tool represented about one-third of the study population, pointing out the significant need for continued professional lactation support (Nommsen-Rivers, 2003). The mean age of breastfeeding cessation was 5.4 days (± 2.2), suggesting a strong association between events occurring during the first 3–5 days of life and the early abandonment of breastfeeding.

TABLE 3-9

LATCH Criteria

	0	*1*	*2*
L Latch	Too sleepy or reluctant No latch achieved	Repeated attempts Hold nipple in mouth Stimulate to suck	Grasps breast Tongue down Lips flanged Rhythmic sucking
A Audible swallowing	None	A few with stimulation	Spontaneous and intermittent < 24 hours Spontaneous and frequent > 24 hours
T Type of nipple	Inverted	Flat	Everted (after stimulation)
C Comfort (breast/nipple)	Engorged Cracked, bleeding, large blisters, or bruises Severe discomfort	Filling Reddened/small blisters or bruises Mild/moderate discomfort	Soft Tender
H Hold (positioning)	Full assist (staff holds infant at breast)	Minimal assist (i.e., elevate head of bed; place pillows for support) Teach one side; mother does the other Staff holds and then mother takes over	No assist from staff Mother able to position/hold infant

Source: Adapted from Jensen, D., Wallace, S., & Kelsay, P. (1994). LATCH: A breastfeeding charting system and documentation tool. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 23,* 27–32.

Maternal Breastfeeding Evaluation Scale (MBFES)

The MBFES (Leff, Jeffries, & Gagne, 1994) consists of 30 items divided into three categories identified as maternal perceptions of successful breastfeeding: (1) maternal enjoyment/role attainment, (2) infant satisfaction/growth, and (3) lifestyle/body image. The MBFES is designed to measure the positive and negative aspects of breastfeeding that mothers deem important in defining successful breastfeeding.

Potential Early Breastfeeding Problem Tool

The Potential Early Breastfeeding Problem Tool (PEBPT) was developed to determine which breastfeeding problems rated highest among breastfeeding mothers (Kearney, Cronenwett, & Barrett, 1990). This tool uses 23 questions with a 4-point Likert scale questionnaire, giving a possible total score of 88. Higher scores indicate that more breastfeeding problems have occurred.

TABLE 3-10

Breastfeeding Assessment Score

Variable	*0*	*1*	*2*
Maternal age (y)	< 21	21–24	> 24
Previous breastfeeding experience	Failure	None	Success
Latching difficulty	Every feeding	Half the feedings	< 3 feedings
Breastfeeding interval (hours between feedings)	> 6	3–6	< 3
Number of bottles of formula before enrollment (Babies were enrolled into the study if they were at least 20 hours old.)	> 2	1	0

Two points each should be subtracted for the presence of previous breast surgery, maternal hypertension during pregnancy, and/or vacuum vaginal delivery.

Source: Adapted from Hall, R. T., Mercer, A. M., Teasley, S. L., McPherson, D. M., Simon, S. D., Santos, S. R., . . . Hipsh, N. E. (2002). A breastfeeding assessment score to evaluate the risk for cessation of breastfeeding by 7 to 10 days of age. *Journal of Pediatrics, 141,* 659–664.

H & H Lactation Scale

The H & H Lactation Scale and its three subscales (maternal confidence/commitment to breastfeeding, perceived infant breastfeeding satiety, and maternal/infant breastfeeding satisfaction) are designed to measure a mother's perception of insufficient milk supply, a leading cause of premature weaning from the breast (Hill & Humenick, 1996). This tool can be used prospectively with both full-term and preterm mothers.

Breastfeeding Self-Efficacy Scale (BSES)

The BSES (Dennis & Faux, 1999) is a 33-item self-report tool that assesses breastfeeding self-efficacy expectations in new mothers. Self-efficacy is the mother's perception regarding her ability to perform a specific behavior—in this case, breastfeeding. The scale is designed to identify mothers with low breastfeeding confidence and to provide assessment information to assist the healthcare provider in creating care plans specific to the items identified as problematic (Dennis, 1999). The BSES was modified to a shortened version (BSES-SF) that keeps 14 items and deletes 18 items that were shown to be redundant, making it easier and quicker to administer (Dennis, 2003).

Breastfeeding Attrition Prediction Tool (BAPT)

The BAPT (Janke, 1992) uses four subscales to measure the theory of planned behavior: positive breastfeeding sentiment (18 items), negative breastfeeding sentiment (9 items), social and professional support (10 items), and control (12 items). The original tool used 49 items to help predict breastfeeding status at 8 weeks postpartum.

Neonatal Oral-Motor Assessment Scale

This scale assesses 28 characteristics of sucking and is used to diagnose both disorganized and dysfunctional sucking (Palmer, Crawley, & Blanco, 1993). This differentiation is often subtle, necessitating that users of the Neonatal Oral-Motor Assessment Scale be certified in the administration and scoring of the tool. Deviations in sucking include a disorganized suck that is defined as a lack of rhythm of the total sucking activity (Crook, 1979), with the infant demonstrating difficulty in coordinating sucking and swallowing with breathing. Clinical signs of disorganized sucking include labored breathing, color changes, apnea, bradycardia, and nasal flaring (Palmer, 1993), often seen with premature infants. Dysfunctional sucking is characterized by abnormality in orofacial tone that may present as minimal jaw excursions, excessively wide jaw excursions, tongue retraction, and/or flaccid tongue (Palmer, 2002). Such situations usually require specialized referrals and follow-up because dysfunctional sucking in the neonate has been correlated with developmental delay at 24 months of age (Hawdon, Beauregard, & Kennedy, 2000; Palmer & Heyman, 1999).

Newborn Individualized Developmental Care and Assessment Program (NIDCAP)

The NIDCAP is an infant behavior assessment system (Als, 1995) originally developed for preterm infants that assesses behavior in the autonomic system (heart rate, respiration, skin color, startles, twitches, gastrointestinal signs), motor system (muscle tone, posture, active movements), state system (level of wakefulness, clarity of state, pattern of state transitions), and attention or interaction (availability, responsiveness). The observation is designed to provide data for descriptions of an infant's strengths and weaknesses, current developmental goals, and recommendations for caregiving, including feeding. NIDCAP observations have been used to guide modifications to the infant's environment and to provide recommendations to facilitate optimal breastfeeding experiences for compromised infants (Nyqvist, Ewald, & Sjoden, 1996a). Most users of the NIDCAP tool are certified in its administration and interpretation.

Preterm Infant Breastfeeding Behavior Scale

The Preterm Infant Breastfeeding Behavior Scale was developed to describe the maturational steps and developmental stages in preterm infant breastfeeding behavior through operational definitions ranging from immature to mature behavior (Nyqvist, Sjoden, & Ewald, 1999). It is also used to reduce the delays in going to breast that commonly occur with preterm infants by quantifying the appearance of parameters necessary for full breastfeeding (Nyqvist, Sjoden, & Ewald, 1999; Nyqvist, Rubertsson, Ewald, & Sjoden, 1996). Maturational steps in preterm infants' breastfeeding behavior are scored for rooting, areolar grasp, latching, sucking, longest sucking burst, and swallowing.

Mother–Infant Breastfeeding Progress Tool

This tool was developed in recognition that both the mother and the infant contribute to the development and success of breastfeeding (Johnson, Mulder, & Strube, 2007). The Mother–Infant Breastfeeding Progress Tool is designed to evaluate the presence of maternal and infant behaviors that are necessary for the mother to independently latch her infant to the breast. The tool is used during breastfeeding and consists of eight items (**Table 3-11**). Rather than using a single score to identify or predict problems and guide interventions, the checklist is not scored but is used over time to assess whether progress toward effective breastfeeding is being made. It is unclear whether swallowing is included under nutritive sucking. If swallowing does not happen, then no milk transfer occurs and the infant is left undernourished even though he or she may be latched to the breast and the mother can independently breastfeed her infant.

Beginning Breastfeeding Survey (BBS)

The BBS is designed to measure the mother's perception of her ability to breastfeed effectively during the first few days postpartum (Mulder & Johnson, 2010). It is designed as a measure of breastfeeding

TABLE 3-11

Mother–Infant Breastfeeding Progress Tool

Mother responds to infant feeding cues	Infant eagerly roots and latches
Mother goes no longer than 3 h between feeding attempts	Infant grasps areolar tissue with mouth open wide, lips visible and flanged outward
	Nutritive sucking bursts noted
Mother independently positions self for feeding	Does not require assistance, including position pillows
Mother can independently latch infant onto breast	Does not require any assistance to position herself or infant for latch
No nipple trauma is present	Includes redness, blistering, bruising, bleeding, or scabbing
No negative comments about breastfeeding	No comments that reflect insecurity about ability to breastfeed or satisfy her infant

Source: Adapted from Johnson, T. S., Mulder, P. J., & Strube, K. (2007). Mother-infant breastfeeding progress tool: A guide for education and support of the breastfeeding dyad. *Journal of Obstetric, Gynecologic, and Neonatal Nursing 36,* 319–327.

effectiveness for a single breastfeeding episode that has already occurred. Each item in the BBS is indicative of an infant or maternal need that is met or unmet. There are 26 items in the tool, 16 maternal need items and 10 infant need items. This tool potentially provides a quick and easy screening method that can be completed during the hospitalization to determine which mothers would benefit from further breastfeeding support in the hospital and following discharge.

Validity and Reliability

The validity and reliability of breastfeeding assessment tools vary depending on a number of issues, including the outcome criteria under study. Some tools were constructed for charting and descriptive purposes, not necessarily for their predictive value. Efforts have been made to scrutinize a number of breastfeeding assessment tools to discover their usefulness in the clinical setting as well as in areas of policy and research. Howe, Lin, Fu, Su, and Hsieh (2008) reviewed seven clinical feeding assessment tools, five of which related to breastfed infants (IBFAT, LATCH, MBS, Preterm Infant Breastfeeding Behavior Scale, and SAIB). They reported that none was satisfactory in terms of being empirically validated. Mixed results of reliability and validity were noted for the LATCH and IBFAT, and limited evidence of psychometric properties was seen for the MBA and SAIB.

LATCH, IBFAT, and MBA

Riordan and Koehn (1997) assessed three tools, LATCH, IBFAT, and MBA, to ascertain whether any or all were accurate predictors of adequate infant intake, especially after discharge. Each tool uses different components to assess effective breastfeeding. Interrater agreement among the tools was low on some of the components. Agreement reached 0.90 (a number on which clinical decisions can be made) on two items in the LATCH tool (audible swallowing and type of nipple), two items in the MBA (readiness to feed and positioning), and no items in the IBFAT. The study concluded that none of these tools was reliable or valid in the clinical setting. No tools used any type of swallow count or weight measurements to determine actual intake at a feeding; nor did the study use these techniques to test validity of the tools.

Raters were maternity nurses who viewed videotapes of feedings and were not present in the clinical setting where the feedings occurred.

Comparisons among existing tools as a way to test validity may be difficult because they measure feedings at the breast in different ways. Thus the results may not be highly correlated to one another (Riordan, 1998).

Hamelim and McLennan (2000) assessed the relationship between the use of the LATCH tool and breastfeeding outcomes, determining that even after the tool went into use in the hospital setting, breastfeeding outcomes did not improve. The authors concluded that the LATCH tool lacked predictive ability. This result could have been related to hospital practices that delayed the first breastfeed for an average of 2 hours and to the fact that 30% of all infants in the study were supplemented with formula during their hospital stay. Individual LATCH scores of breastfeeding sessions in the hospital setting were not collected.

Adams and Hewell (1997) compared maternally derived LATCH scores and professional LATCH scores to see whether relationships existed between these measures and maternal reports of satisfaction with breastfeeding. Their results showed moderate correlations overall but significant discrepancies in specific areas. The weakest correlations between mother and professional assessments were in the areas of audible swallowing and positioning, where the maternal assessments were less accurate. These areas involve assessing the infant's contribution to breastfeeding rather than the mother's contribution. As the maternal scores increased on the LATCH, mothers ranked themselves as being more satisfied with breastfeeding. The interrater agreement between the researcher and the clinic lactation consultants for total LATCH scores was 94.4%. The interrater agreement was greater than 85% (range, 85.7–100%) for each of the five LATCH components, supporting the reliability of the LATCH as an effective tool for professional assessment of breastfeeding and for the communication of those findings. This conclusion contradicts the findings of Riordan and Koehn, possibly because the Riordan study used maternity nurses who evaluated videotaped breastfeeding sessions, whereas this study used lactation consultants who were physically present to evaluate each feeding.

Kumar, Mooney, Wieser, and Havstad (2006) determined whether LATCH scores assessed by professional staff during in-hospital stays were predictive of breastfeeding at 6 weeks. A score of 9 or above at 16 to 24 hours was the most discriminate of the five time periods examined. Women who met this criterion were 1.7 times more likely to be breastfeeding at 6 weeks compared with women with lower scores. LATCH scores lower than 9 at 16 to 24 hours after birth should be an indicator that more intensive breastfeeding support is needed.

Tornese et al. (2012) analyzed the relationship between the LATCH score assessed in the first 24 hours after delivery and non-exclusive breastfeeding at discharge. Their goal was to identify a cutoff for the LATCH score for the purpose of identifying women with higher risk of non-exclusive breastfeeding who may need additional lactation support. The rate of non-exclusive breastfeeding was inversely related to the LATCH score, with non-exclusively breastfeeding infants scoring less (6.9) than infants exclusively breastfed at discharge (7.6). The authors were unable to identify a single LATCH cutoff score that could consistently predict non-exclusive breastfeeding at discharge. However, three subgroups and their cutoff scores for exclusive breastfeeding at discharge were identified. Cesarean delivery was considered a major risk factor for non-exclusive breastfeeding, and phototherapy and primiparity were considered minor factors. In the high-risk group (either presenting with the major risk factor or both minor risk factors), extra support should be provided regardless of the LATCH score. In the presence of both minor risk factors, extra breastfeeding support should be provided to all mothers with a LATCH score of 9 or below. In the moderate-risk group (presence of one minor risk factor), the LATCH score is predictive for non-exclusive breastfeeding and the need for extra support when it is equal to or below 6 when the risk factor is phototherapy and 4 when the risk factor is primiparity.

LATCH/IBFAT and MBFES/PEBPT

The LATCH and IBFAT tools and the MBFES and PEBPT tools were assessed to see whether a relationship existed between scores on the LATCH/IBFAT breastfeeding assessment and maternal satisfaction (MBFES) and breastfeeding problems (PEBPT) experienced at 1 week postpartum (Schlomer, Kemmerer, & Twiss, 1999). A moderate association was seen: As the scores on both the LATCH and IBFAT increased, maternal satisfaction scores increased and breastfeeding problem scores tended to decrease.

The LATCH tool was assessed for its validity in predicting breastfeeding status at 6 weeks postpartum. Mothers who scored lower on the comfort domain (engorged, cracked, or bleeding nipples) were less likely to be breastfeeding at 6 weeks, despite their intention to feed at least that long (Riordan, Bibb, Miller, & Rawlins, 2001). The LATCH tool proved useful in identifying the need for follow-up with breastfeeding mothers at risk for early weaning because of sore nipples. The authors recommend that mothers who score 2 or lower on the comfort measure be closely followed after discharge.

Riordan, Woodley, and Heaton (1994) tested the validity and reliability of the MBFES as a way to directly measure maternal satisfaction with breastfeeding. The MBFES scale and subscales were positively correlated with the length of time the mother intended to breastfeed as well as the length of time she actually breastfed. Maternal satisfaction with breastfeeding was also positively linked to the length of time mothers intended to breastfeed. The MBFES was found to be a valid and reliable tool and was useful for measuring outcomes of interventions such as breastfeeding classes or breastfeeding rounds.

Low breastfeeding satisfaction as measured by the MBFES appeared to be the most important predictor of weaning at survey ages of 6 weeks and 3 months, even after adjusting for other breastfeeding experiences (Cooke, Sheehan, & Schmied, 2003). Most breastfeeding problems were not predictive of weaning. Mothers with low breastfeeding satisfaction scores were 3–15 times more likely to wean during the 2-week, 6-week, and 3-month survey periods in the Cooke study.

H & H Lactation Scale

The H & H Lactation Scale and its three subscales were found to have a high degree of reliability as well as concurrent and predictive validity when used prospectively with breastfeeding mothers of both full-term and preterm infants (Hill & Humenick, 1996). The tool's predictive ability suggested that a mother's perception of insufficient milk supply was most closely tied to her perception of infant satiety.

BSES

Predictive validity for the BSES was demonstrated with positive correlations between BSES scores and infant feeding patterns at 6 weeks postpartum. The BSES was found to be valid and reliable in predicting which women would still be breastfeeding at 6 weeks (Dennis & Faux, 1999). In other words, the higher the BSES score, the more likely the mother would be exclusively breastfeeding at 6 weeks postpartum. The BSES was also shown to be significantly related to breastfeeding duration and intensity (exclusivity).

Low antenatal breastfeeding self-efficacy scores were positively related to bottle-feeding at 1 week postpartum. High self-efficacy scores at 1 week postpartum were related to mothers being more likely to continue to breastfeed until 4 months postpartum and to do so exclusively (Blyth et al., 2002). The BSES has been translated into Spanish and replicated in a sample of 100 Puerto Rican women. It was found to be a valid and reliable measure of breastfeeding confidence among Puerto Rican mothers (Torres, Torres, Rodriguez, & Dennis, 2003). This tool has also been translated into Mandarin Chinese and shown to be a reliable and valid instrument when administered to 186 Chinese mothers (Dai & Dennis, 2003). The short form, BSES-SF, proved both valid and reliable in identifying mothers who needed additional interventions as well as pointing out that mothers who delivered via cesarean had lower self-efficacy in breastfeeding than those who delivered vaginally (Dennis, 2003).

BAPT

Janke (1994) established construct validity of the BAPT by factor analysis. The original BAPT was able to predict breastfeeding status at 8 weeks in 73% of the mother studies (Janke, 1994). Shortening the instrument increased its reliability scores while maintaining adequate prediction of early attrition. The modified BAPT was an effective predictor of 78% of women who stopped breastfeeding before 8 weeks and 68% of those who were still breastfeeding at that time (Dick et al., 2002). These results were consistent with Wambach's results that showed a mother's attitude and sense of control were the strongest predictors of breastfeeding behavior (Wambach, 1997). Evans, Dick, Lewallen, and Jeffrey (2004) determined that the BAPT was not an effective predictor of early breastfeeding attrition at either the prenatal or postpartum administration of the tool.

BBS

The BBS demonstrated more than adequate internal consistency reliability for a new scale. The BBS was positively correlated with breastfeeding self-efficacy. The group of mothers who were exclusively breastfeeding scored higher than either of the groups of partial breastfeeding or full formula-feeding.

Review of Assessment Tools

Ho and McGrath (2010) conducted a review of seven tools used to assess women's attitudes, experiences, satisfaction, and confidence toward breastfeeding; the Gender-Role Attitudes toward Breastfeeding Scale (GRABS) developed by Kelley, Kviz, Richman, Kim, and Short (1993) used to measure new mother's attitudes and behaviors toward breastfeeding; the Iowa Infant Feeding Attitudes Scale (IIFAS) developed by De la Mora and Russell (1999) to measure attitudes toward infant feeding and to identify factors that influence women's decisions related to infant feeding methods; the MBFES; the BSES; the H & H Lactation Scale; the Breastfeeding Personal Efficacy Beliefs Inventory (BPEBI) developed by Cleveland and McCrone (2005); and the BAPT. Overall, Ho and McGrath (2010) found that these tools were valid, reliable, and feasible self-report measures of attitudes, satisfaction, experiences, or confidence associated with breastfeeding. Clinicians should understand that modifying any of these tools or testing the tools in populations different than the ones in the studies may alter the psychometric properties of the tool and may require testing of the modifications and new populations.

SUMMARY: THE DESIGN IN NATURE

The human infant, although born immature in many regards, is uniquely adapted to secure food and nurturance from the maternal breast right from the start. Alterations in the infant's anatomy and physiology may temporarily (or rarely permanently) affect his or her ability to feed at the breast, but breastmilk can almost always be fed to the infant. Prompt recognition of deviations and appropriate referrals and follow-up often permit breastfeeding or the provision of breastmilk in even the most extreme situations. All infants benefit from human milk, especially in the presence of anatomic or physiological compromise.

REFERENCES

Adams, D., & Hewell, S. (1997). Maternal and professional assessment of breastfeeding. *Journal of Human Lactation, 13,* 279–283.

Aizawa, M., Mizuno, K., & Tamura, M. (2010). Neonatal sucking behavior—Comparison of perioral movement during breastfeeding and bottle feeding. *Pediatrics International, 52,* 104–108.

Alcantara, J., & Anderson, R. (2008). Chiropractic care of a pediatric patient with symptoms associated with gastroesophageal reflux disease, fuss-cry-irritability with sleep disorder syndrome and irritable infant syndrome of musculoskeletal origin. *Journal of the Canadian Chiropractic Association, 52,* 248–255.

Als, H. (1995). *Manual for the naturalistic observation of newborn behavior. Newborn Individualized Developmental Care and Assessment Program (NIDCAP).* Boston: Harvard Medical School.

Amaizu, N., Shulman, R. J., Schanler, R. J., & Lau, C. (2008). Maturation of oral feeding skills in preterm infants. *Acta Paediatrica, 97,* 61–67.

American Academy of Pediatrics, Committee on Fetus and Newborn. (2004). Hospital stay for healthy term newborns. *Pediatrics, 113,* 1434–1436.

Ardran, G. M., Kemp, F. H., & Lind, J. (1958). A cineradiographic study of breast feeding. *British Journal of Radiology, 31,* 156–162.

Arguin, A. L., & Swartz, M. K. (2004). Gastroesophageal reflux in infants: A primary care perspective. *Pediatric Nursing, 30,* 45–71.

Arvedson, J. C., & Lefton-Greif, M. A. (1998). *Pediatric videofluoroscopic swallow studies.* San Antonio, TX: Communication Skill Builders.

Ballard, J. L., Auer, C. E., & Khoury, J. C. (2002). Ankyloglossia: Assessment, incidence, and effect of frenuloplasty on the breastfeeding dyad. Pediatrics, 110:e63. Retrieved from http://www.pediatrics.org/cgi/content/full/110/5/e63

Biancuzzo, M. (1998). Yes! Infants with clefts can breastfeed. *AWHONN Lifelines, 2,* 45–49.

Bibi, H., Khvolis, E., Shoseyov, D., Ohaly, M., Ben Dor, D., London, D., & Ater, D. (2001). The prevalence of gastroesophageal reflux in children with tracheomalacia and laryngomalacia. *Chest, 119,* 409–413.

Blair, A., Cadwell, K., Turner-Maffei, C., & Brimdyr, K. (2003). The relationship between positioning, the breastfeeding dynamic, the latching process and pain in breastfeeding mothers with sore nipples. *Breastfeeding Review, 11,* 5–10.

Blyth, R., Creedy, D. K., Dennis, C.-L., Moyle, W., Pratt, J., & Vries, S. M. (2002). Effect of maternal confidence on breastfeeding duration: An application of breastfeeding self-efficacy theory. *Birth, 29,* 278–284.

Boekel, S. (2000). *Gastroesophageal reflux disease (GERD) and the breastfeeding baby.* Independent Study Module. Raleigh, NC: International Lactation Consultant Association.

Boere-Boonekamp, M., & van der Linden-Kuiper, L. (2001). Positional preference: Prevalence in infants and follow-up after two years. *Pediatrics, 107,* 339–343.

Bono, B. J. (1992). Assessment and documentation of the breastfeeding couple by health care professionals. *Journal of Human Lactation, 8,* 17–22.

Borrelli, O., Marabotto, C., Mancini, V., Aloi, M., Macri, F., Falconieri, P., . . . Cucchiara, S. (2011). Role of gastroesophageal reflux in children with unexplained chronic cough. *Journal of Pediatric Gastroenterology and Nutrition, 53,* 287–292.

Bosma, J. F., Hepburn, L. G., Josell, S. D., & Baker, K. (1990). Ultrasound demonstration of tongue motions during suckle feeding. *Developmental Medicine and Child Neurology, 32,* 223–229.

Bowen-Jones, A., Thompson, C., & Drewett, R. F. (1982). Milk flow and sucking rate during breastfeeding. *Developmental Medicine and Child Neurology, 24,* 626–633.

Bromiker, R., Rachamim, A., Hammerman, C., Schimmel, M., Kaplan, M., Medoff-Cooper, B. (2006). Immature sucking patterns in infants of mothers with diabetes. *Journal of Pediatrics, 149,* 640–643.

Byrnes, A. L., Berk, N. W., Cooper, M. E., & Marazita, M. L. (2003). Parental evaluation of informing interviews for cleft lip and/or palate. *Pediatrics, 112,* 308–313.

Carrascoza, K. C., Possobon, R. de F., Tomita, L. M., de Moraes, A. B. A. (2006). Consequences of bottle-feeding to the oral facial development of initially breastfed children. *Journal of Pediatrics, (Rio J), 82,* 395–397.

Chetwynd, A. G., Diggle, P. J., Drewett, R. F., & Young, B. (1998). A mixture model for sucking patterns of breastfed infants. *Statistics in Medicine, 17,* 395–405.

Cleveland, A. P., & McCrone, S. (2005). Development of the breastfeeding personal efficacy beliefs inventory: A measure of womens' confidence about breastfeeding. *Journal of Nursing Measurement, 13,* 115–127.

Cooke, M., Sheehan, A., & Schmied, V. (2003). A description of the relationship between breastfeeding experiences, breastfeeding satisfaction, and weaning in the first 3 months after birth. *Journal of Human Lactation, 19,* 145–156.

Crelin, E. (1976). Development of the upper respiratory system. *Ciba Clinical Symposia, 28,* 12.

Crook, C. K. (1979). The organization and control of infant sucking. *Advances in Child Development and Behavior, 14,* 209–252.

Dai, X., & Dennis, C. L. (2003). Translation and validation of the Breastfeeding Self-Efficacy Scale into Chinese. *Journal of Midwifery and Women's Health, 48,* 350–356.

De La Mora, A., & Russell, D. W. (1999). The Iowa Infant Feeding Attitude Scale: Analysis of reliability and validity. *Journal of Applied Social Psychology, 29,* 2362–2380.

Dennis, C.-L. (1999). Theoretical underpinnings of breastfeeding confidence: A self-efficacy framework [Commentary]. *Journal of Human Lactation, 15,* 195–201.

Dennis, C.-L. (2003). The Breastfeeding Self-Efficacy Scale: Psychometric assessment of the short form. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 32,* 734–744.

Dennis, C.-L., Faux, S. (1999). Development and psychometric testing of the Breastfeeding Self-Efficacy Scale. *Research in Nursing Health, 22,* 399–409.

Dick, M. J., Evans, M. L., Arthurs, J. B., Barnes, J. K., Caldwell, R. S., Hutchins, S. S., & Johnson, L. K. (2002). Predicting early breastfeeding attrition. *Journal of Human Lactation, 18,* 21–28.

Dowling, D., Danner, S., & Coffey, P. (1997). *Breastfeeding the infant with special needs.* White Plains, NY: March of Dimes.

Drewett, R. F., & Woolridge, M. (1981). Milk taken by human babies from the first and second breast. *Physiology and Behavior, 26,* 327–329.

Duara, S. (1989). Oral feeding containers and their influence on intake and ventilation in preterm infants. *Biology of the Neonate, 56,* 270–276.

Edmondson, R., & Reinhartsen, D. (1998). The young child with cleft lip and palate: Intervention needs in the first three years. *Infants and Young Children, 11,* 12–20.

Edmunds, J., Miles, S. C., & Fulbrook, P. (2011). Tongue-tie and breastfeeding: A review of the literature. *Breastfeeding Review, 19,* 19–26.

Egnell, E. (1956). The mechanism of different methods of emptying the female breast. *Journal of the Swedish Medical Association, 40,* 1–8.

Evans, M. L., Dick, M. J., Lewallen, L. P., & Jeffrey, C. (2004). Modified breastfeeding attrition prediction tool: Prenatal and postpartum tests. *Journal of Perinatal Education, 13,* 1–8.

Fernando, C. (1998). *Tongue tie: From confusion to clarity.* Sydney, Australia: Tandem Publications.

Geddes, D. T., Chadwick, L. M., Kent, J. C., Garbin, C. P., & Hartmann, P. E. (2010a). Ultrasound imaging of infant swallowing during breastfeeding. *Dysphagia, 25,* 183–191.

Geddes, D. T., Kent, J. C., McClellan, H. L., Garbin, C. P., Chadwick, L. M., & Hartmann, P. E. (2010b). Sucking characteristics of successfully breastfeeding infants with ankyloglossia: A case series. *Acta Paediatrica, 99,* 301–303.

Geddes, D. T., Kent, J. C., Mitoulas, L. R., & Hartmann, P. E. (2008). Tongue movement and intra-oral vacuum in breastfeeding infants. *Early Human Development, 84,* 471–477.

Geddes, D. T., Sakalidis, V. S., Hepworth, A. R., McClellan, H. L., Kent, J. C., Lai, C. T., & Hartmann, P. E. (2012). Tongue movement and intra-oral vacuum of term infants during breastfeeding and feeding from an experimental teat that released milk under vacuum only. *Early Human Development, 88,* 443–449.

Gewolb, I. H., Vice, F. L., Schweitzer-Kenney, E. L., Taciak, V. L., & Bosma, J. F. (2001). Developmental patterns of rhythmic suckle and swallow in preterm infants. *Developmental Medicine and Child Neurology, 43,* 22–27.

Glass, R. P., & Wolf, L. S. (1999). Feeding management of infants with cleft lip and palate and micrognathia. *Infants and Young Children, 12,* 70–81.

Goldfield, E. C., Richardson, M. J., Lee, K. G., & Margetts, S. (2006). Coordination of sucking, swallowing, and breathing and oxygen saturation during early infant breastfeeding and bottle-feeding. *Pediatric Research, 59,* 1–7.

Gomes, C. F., Thomson, Z., & Cardoso, J. R. (2009). Utilization of surface electromyography during the feeding of term and preterm infants: A literature review. *Developmental Medicine and Child Neurology, 51,* 936–942.

Gomes, C. F., Trezza, E. M. C., Murade, E. C. M., & Padovani, C. R. (2006). Surface electromyography of facial muscles during natural and artificial feeding of infants. *Journal of Pediatrics (Rio J), 82,* 103–109.

Habel, A., Elhadi, N., Sommerlad, B., & Powell, J. (2006). Delayed detection of cleft palate: An audit of newborn examination. *Archives of Disease in Childhood, 91,* 238–240.

Hall, R. T., Mercer, A. M., Teasley, S. L., McPherson, D. M., Simon, S. D., Santos, S. R., . . . Hipsh, N. E. (2002). A breastfeeding assessment score to evaluate the risk for cessation of breastfeeding by 7 to 10 days of age. *Journal of Pediatrics, 141,* 659–664.

Hamelin, K., & McLennan, J. (2000). Examination of the use of an in-hospital breastfeeding assessment tool. *Mother and Baby Journal, 5,* 29–37.

Hawdon, J. M., Beauregard, N., & Kennedy, G. (2000). Identification of neonates at risk of developing feeding problems in infancy. *Developmental Medicine and Child Neurology, 42,* 235–239.

Hazelbaker, A. K. (1993). *The Assessment Tool for Lingual Frenulum Function (ATLFF): Use in a lactation consultant private practice* (Thesis). Pasadena, CA: Pacific Oaks College.

Hill, P., & Humenick, S. (1996). Development of the H & H Lactation Scale. *Nursing Research, 45,* 136–140.

Ho, Y.-J., & McGrath, J. K. (2010). A review of the psychometric properties of breastfeeding assessment tools. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 39,* 386–400.

Hohoff, A., Rabe, H., Ehmer, U., & Harms, E. (2005). Palatal development of preterm and low birthweight infants compared to term infants—What do we know? Part 1: The palate of the term newborn. *Head and Face Medicine, I,* 8.

Howe, T.-H., Lin, K.-C., Fu, C.-P., Su, C.-T., & Hsieh, C.-L. (2008). A review of psychometric properties of feeding assessment tools used in neonates. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 37,* 338–349.

Iskander, A., & Sanders, I. (2003). Morphological comparison between neonatal and adult human tongues. *Annals of Otology, Rhinology, and Laryngology, 112,* 768–776.

Jacinto-Goncalves, S. R., Gaviao, M. B., Berzin, F., de Oliveira, A. S., & Semeguini, T. A. (2004). Electromyographic activity of perioral muscle in breastfed and non-breastfed children. *Journal of Clinical Pediatric Dentistry, 29,* 57–62.

Jacobs, L. A., Dickinson, J. E., Hart, P. D., Doherty, D. A., & Faulkner, S. J. (2007). Normal nipple position in term infants measured on breastfeeding ultrasound. *Journal of Human Lactation, 23,* 52–59.

Jadcherla, S. R., Chan, C. Y., Moore, R., Malkar, M., Timan, C. J., & Valentine, C. J. (2012). Impact of feeding strategies on the frequency and clearance of acid and nonacid gastroesophageal reflux events in dysphagic neonates. *Journal of Parenteral and Enteral Nutrition, 36(4),* 449–455.

Janke, J. R. (1992). Prediction of breastfeeding attrition: Instrument development. *Applied Nursing Research, 5,* 48–53.

Janke, J. R. (1994). Development of the Breastfeeding Attrition Prediction Tool. *Nursing Research, 43,* 100–104.

Jean, A. (2001). Brain stem control of swallowing: Neuronal network and cellular mechanisms. *Physiology Review, 81,* 929–969.

Jenks, M. (1991). Latch assessment documentation in the hospital nursery. *Journal of Human Lactation, 7,* 19–20.

Jensen, D., Wallace, S., & Kelsay, P. (1994). LATCH: A breastfeeding charting system and documentation tool. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 23,* 27–32.

Johnson, T. S., Mulder, P. J., & Strube, K. (2007). Mother-infant breastfeeding progress tool: A guide for education and support of the breastfeeding dyad. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 36,* 319–327.

Jung, A. D. (2001). Gastroesophageal reflux in infants and children. *American Family Physician, 64,* 1853–1860.

Kearney, M., Cronenwett, L., & Barrett, J. (1990). Breastfeeding problems in the first week postpartum. *Nursing Research, 39,* 90–95.

Kelley, M. A., Kviz, F., Richman, J. A., Kim, J. H., & Short, C. (1993). Development of a scale to measure gender-role attitudes toward breastfeeding among primiparas. *Women and Health, 20,* 47–68.

Kelly, B. N., Huckabee, M-L., Jones, R. D., & Frampton, C. M. A. (2007). The early impact of feeding on infant breathing-swallowing coordination. *Respiratory Physiology and Neurobiology, 156,* 147–153.

Kent, J. C., Mitoulas, L. R., Cregan, M. D., Geddes, D. T., Larsson, M., Doherty, D. A., & Hartmann, P. E. (2008). Importance of vacuum for breastmilk expression. *Breastfeeding Medicine, 3,* 11–19.

Kent, J. C., Ramsay, D. T., Doherty, D., Larsson, M., & Hartmann, P. E. (2003). Response of breasts to different stimulation patterns of an electric breast pump. *Journal of Human Lactation, 19,* 179–186.

Kotlow, L. (2004a). Oral diagnosis of abnormal frenum attachments in neonates and infants: Evaluation and treatment of the maxillary and lingual frenum using the Erbium: YAG laser. *Journal of Pediatric Dental Care, 10,* 11–14.

Kotlow, L. (2004b). Oral diagnosis of abnormal frenum attachments in neonates and infants. *Journal of Pediatric Dental Care, 10,* 26–28.

Kotlow, L. A. (2004c). Using the Erbium: YAG laser to correct an abnormal lingual frenum attachment in newborns. *Journal of the Academy of Laser Dentistry, 12,* 22–23.

Kotlow, L. (2011a). Diagnosis and treatment of ankyloglossia and tied maxillary fraenum in infants using Er:YAG and 1064 diode lasers. *European Archives in Paediatric Dentistry, 12,* 106–112.

Kotlow, L. (2011b). Infant reflux and aerophagia associated with the maxillary lip-tie and ankyloglossia (tongue-tie). *Clinical Lactation, 2,* 25–29.

Kron, R. E., & Litt, M. (1971). Fluid mechanics of nutritive sucking behaviour: The suckling infant's oral apparatus analysed as a hydraulic pump. *Medical and Biological Engineering, 9,* 45–60.

Kumar, M., & Kalke, E. (2012). Tongue-tie, breastfeeding difficulties and the role of frenotomy. *Acta Paediatrica* [Ahead of print].

Kumar, S. P., Mooney, R., Wieser, L. J., & Havstad, S. (2006). The LATCH scoring system and prediction of breastfeeding duration. *Journal of Human Lactation, 22,* 391–397.

Lau, C., Sheena, H. R., Shulman, R. J., & Schanler, R. J. (1997). Oral feeding in low birth weight infants. *Journal of Pediatrics, 130,* 561–569.

Leff, E., Jeffries, S., Gagne, M. (1994). The development of the Maternal Breastfeeding Evaluation Scale. *Journal of Human Lactation, 10,* 105–111.

Marmet, C., & Shell, E. (1993). Lactation forms: A guide to lactation consultant charting (pp. 4–7). Encino, CA: Lactation Institute and Breastfeeding Clinic.

Marmet, C., Shell, E., & Marmet, R. (1990). Neonatal frenotomy may be necessary to correct breastfeeding problems. *Journal of Human Lactation, 6,* 117–121.

Masarei, A. G., Sell, D., Habel, A., Mars, M., Sommerlad, B. C., & Wade, A. (2007). The nature of feeding in infants with unrepaired cleft lip and/or palate compared with healthy noncleft infants. *Cleft Palate-Craniofacial Journal, 44,* 321–328.

Mathew, O. P. (1988). Respiratory control during nipple feeding in preterm infants. *Pediatric Pulmonology, 5,* 220–224.

Mathew, O. P. (1991a). Science of bottle feeding. *Journal of Pediatrics, 119,* 511–519.

Mathew, O. P. (1991b). Breathing patterns of preterm infants during bottle feeding: Role of milk flow. *Journal of Pediatrics, 119,* 960–965.

Mathew, O. P., & Bhatia, J. (1989). Sucking and breathing patterns during breast- and bottle-feeding in term neonates. *American Journal of Diseases in Childhood, 143,* 588–592.

Matthews, M. K. (1988). Developing an instrument to assess infant breastfeeding behaviour in the early neonatal period. *Midwifery, 4,* 154–165.

Matthews, M. K. (1991). Mothers' satisfaction with their neonates' breastfeeding behaviors. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 20,* 49–55.

Matthews, M. K. (1993). Assessments and suggested interventions to assist newborn breastfeeding behavior. *Journal of Human Lactation, 9,* 243–248.

McClellan, H. L., Geddes, D. T., Kent, J. C., Garbin, C. P., Mitoulas, L. R., & Hartmann, P. E. (2008). Infants of mothers with persistent nipple pain exert strong sucking vacuums. *Acta Paediatrica, 97,* 1205–1209.

McClellan, H. L., Sakalidis, V. S., Hepworth, A. R., Hartmann, P. E., & Geddes, D. T. (2010). Validation of nipple diameter and tongue movement measurements with B-mode ultrasound during breastfeeding. *Ultrasound in Medicine and Biology, 36,* 1197–1807.

Medeiros, A. P. M., Ferreira, J. T. L., & de Felicio, C. M. (2009). Correlation between feeding methods, non-nutritive sucking and orofacial behaviors. *Pro-fono Revista de Atualizacao Cientifica, 21,* 315–319.

Meier, P. P. (1988). Bottle and breastfeeding: Effects on transcutaneous oxygen pressure and temperature in preterm infants. *Nursing Research, 37,* 36–41.

Meier, P. P. (1996). Suck-breathe patterning during bottle and breastfeeding for preterm infants. In J. J. David (Ed.), *Major controversies in infant nutrition* (pp. 9–20). International Congress and Symposium Series 215. London: Royal Society of Medicine Press.

Meier, P. P. (2001). Breastfeeding in the special care nursery: Prematures and infants with medical problems. *Pediatric Clinics of North America, 48,* 425–442.

Meier, P. P. (2003). Supporting lactation in mothers with very low birth weight infants. *Pediatric Annals, 32,* 317–325.

Meier, P. P., Lysakowski, T. Y., Engstrom, J. L., Kavanaugh, K. L., & Mangurten, H. H. (1990). The accuracy of test-weighing for preterm infants. *Journal of Pediatric Gastroenterology and Nutrition, 10,* 62–65.

Messner, A. H., Lalakea, L., Aby, J., Macmahon, J., & Bair, E. (2000). Ankyloglossia: Incidence and associated feeding difficulties. *Archives of Otolaryngology—Head and Neck Surgery, 126,* 36–39.

Miller, M. J., Martin, R. J., Carlo, W. A., Fouke, J. M., Strohl, K. P., & Fanaroff, A. A. (1985). Oral breathing in newborn infants. *Journal of Pediatrics, 107,* 465–469.

Mizuno, K, Ueda, A., & Takeuchi, T. (2002). Effects of different fluids on the relationship between swallowing and breathing during nutritive sucking in neonates. *Biology of the Neonate, 81,* 45–50.

Monaci, G., & Woolridge, M. (2011, September). *Ultrasound video analysis for understanding of infant breastfeeding.* International Conference on Signal Processing. IEEE, Belgium.

Moral, A., Bolibar, I., Seguranyes, G., Ustrell, J. M., Sebastia, G., Martinez-Barba, C., & Rios, J. (2010). Mechanics of sucking: Comparison between bottle feeding and breastfeeding. *BMC Pediatrics, 10,* 6.

Morris, S. E., & Klein, M. D. (2000). *Pre-feeding skills: A comprehensive resource for mealtime development* (2nd ed). San Antonio, TX: Therapy Skill Builders.

Mukai, S., Mukai, C., & Asaoka, K. (1991). Ankyloglossia with deviation of the epiglottis and larynx. *Annals of Otology, Rhinology, and Laryngology, 100,* 3–20.

Mulder, P. J., & Johnson, T. S. (2010). The Beginning Breastfeeding Survey: Measuring mothers' perceptions of breastfeeding effectiveness during postpartum hospitalization. *Research in Nursing Health, 33,* 329–344.

Mulford, C. (1992). The Mother-Baby Assessment (MBA): An "Apgar score" for breastfeeding. *Journal of Human Lactation, 8,* 79–82.

Nommsen-Rivers, L. (2003). Research Spotlight. Identifying mothers at risk for early abandonment of breastfeeding. *Journal of Human Lactation, 19,* 217–218.

Notestine, G. E. (1990). The importance of the identification of ankyloglossia (short lingual frenulum) as a cause of breastfeeding problems. *Journal of Human Lactation, 6,* 113–115.

Nyqvist, K. H., Ewald, U., & Sjoden, P.-O. (1996). Supporting a preterm infant's behaviour during breastfeeding: A case report. *Journal of Human Lactation, 12,* 221–228.

Nyqvist, K. H., Rubertsson, C., Ewald, U., & Sjoden, P.-O. (1996). Development of the Preterm Infant Breastfeeding Behavior Scale (PIBBS): A study of nurse–mother agreement. *Journal of Human Lactation, 12,* 207–219.

Nyqvist, K. H., Sjoden, P.-O., & Ewald, U. (1999). The development of preterm infants' breastfeeding behavior. *Early Human Development, 55,* 247–264.

Page, D. C. (2001). Breastfeeding and early functional jaw orthopedics (an introduction). *Functional Orthodontist, 18,* 24–27.

Palmer, B. (1998). The influence of breastfeeding on the development of the oral cavity: A commentary. *Journal of Human Lactation, 14,* 93–98.

Palmer, M. M. (1993). Identification and management of the transitional suck pattern in premature infants. *Journal of Perinatal and Neonatal Nursing, 7,* 66–75.

Palmer, M. M. (2002). Recognizing and resolving infant suck difficulties. *Journal of Human Lactation, 18,* 166–167.

Palmer, M. M., Crawley, K., & Blanco, I. (1993). The Neonatal Oral-Motor Assessment Scale: A reliability study. *Journal of Perinatology, 13,* 28–35.

Palmer, M. M., & Heyman, M. B. (1999). Developmental outcome for neonates with dysfunctional and disorganized sucking patterns: Preliminary findings. *Infant-Toddler Intervention: Transdisciplinary Journal, 9,* 299–308.

Peitsch, W. K., Keefer, C. H., LaBrie, R. A., & Mulliken, J. B. (2002). Incidence of cranial asymmetry in healthy newborns. *Pediatrics, 110*(6). Retrieved from http://www.pediatrics.org/cgi/content/full/110/6/e72

Peterson, A., & Harmer, M. (2010). Balancing breast and bottle: Reaching your breastfeeding goals. Amarillo, TX: Hale Publishing.

Pressler, J. L., Hepworth, J. T., LaMontagne, L. L., Sevcik, R. H., & Hesselink, L. F. (1999). Behavioral responses of newborns of insulin-dependent and nondiabetic healthy mothers. *Clinical Nursing Research, 8,* 103–118.

Prieto, C. R., Cardenas, H., Salvatierra, A. M., Boza, C., Montes, C. G., & Croxatto, H. B. (1996). Sucking pressure and its relationship to milk transfer during breastfeeding in humans. *Journal of Reproductive Fertility, 108,* 69–74.

Ramsay, D. T., Kent, J. C., Owens, R. A., & Hartmann, P. E. (2001, September). *Ultrasound imaging of milk ejection in the human lactating breast* (Abstract 30). Society for Reproductive Biology, Proceedings of the Thirty-Second Annual Conference, Gold Coast, Queensland.

Ramsay, M., & Gisel, E. G. (1996). Neonatal sucking and maternal feeding practices. *Developmental Medicine and Child Neurology, 38,* 34–47.

Reid, J., Kilpatrick, N., & Reilly, S. (2006). A prospective, longitudinal study of feeding skills in a cohort of babies with cleft conditions. *Cleft Palate-Craniofacial Journal, 43,* 702–709.

Reid, J., Reilly, S., & Kilpatrick, N. (2007). Sucking performance of babies with cleft conditions. *Cleft Palate-Craniofacial Journal, 44,* 312–320.

Reiter, R., Brosch, S., Ludeke, M., Fischbein, E., Haase, S., Pickhard, A., . . . Maier, C. (2012). Genetic and environmental risk factors for submucous cleft palate. *European Journal of Oral Science, 120,* 97–103.

Riordan, J. (1998). Predicting breastfeeding problems. *AWHONN Lifelines, 2,* 31–33.

Riordan, J., Bibb, D., Miller, M., & Rawlins, T. (2001). Predicting breastfeeding duration using the LATCH breastfeeding assessment tool. *Journal of Human Lactation, 17,* 20–23.

Riordan, J. M., & Koehn, M. (1997). Reliability and validity testing of three breastfeeding assessment tools. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 26,* 181–187.

Riordan, J., & Riordan, S. (2000). *The effect of labor epidurals on breastfeeding.* Unit 4/Lactation Consultant Series Two. Schaumburg, IL: La Leche League International.

Riordan, J. M., Woodley, G., & Heaton, K. (1994). Testing validity and reliability of an instrument which measures maternal evaluation of breastfeeding. *Journal of Human Lactation, 10,* 231–235.

Sakalidis, V. S., McClellan, H. L., Hepworth, A. R., Kent, J. C., Lai, C. T., Hartmann, P. E., & Geddes, D. T. (2012b). Oxygen saturation and suck-swallow-breathe coordination of term infants during breastfeeding and feeding from a teat releasing milk only with vacuum. *Internatinal Journal of Pediatrics, 2012,* Article ID 130769, doi:10.1155/2012/130769.

Sakalidis, V. S., Williams, T. M., Garbin, C. P., Hepworth, A. R., Hartmann, P. E., Paech, M. J., & Geddes, D. T. (2012a). Ultrasound imaging of infant sucking dynamics during the establishment of lactation. *Journal of Human Lactation* [Epub ahead of print.]

Sanchez-Molins, M., Carbo, J. G., Gaig, C. L., & Torrent, J. M. U. (2010). Comparative study of the craniofacial growth depending on the type of lactation received. *European Journal of Paediatric Dentistry, 11,* 87–92.

Schlomer, J. A., Kemmerer, J., & Twiss, J. J. (1999). Evaluating the association of two breastfeeding assessment tools with breastfeeding problems and breastfeeding satisfaction. *Journal of Human Lactation, 15,* 35–39.

Segami, Y., Mizuno, K., Taki, M., & Itabashi, K. (2012). Perioral movements and sucking pattern during bottle feeding with a novel, experimental teat are similar to breastfeeding. *Journal of Perinatology* [Epub ahead of print]

Shawker, T. H., Sonies, B., Stone, M., & Baum, B. J. (1983). Real-time ultrasound visualization of tongue movement during swallowing. *Journal of Clinical Ultrasound, 11,* 485–490.

Shrago, L., & Bocar, D. (1990). The infant's contribution to breastfeeding. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 19,* 209–215.

Smith, L. J. (2004). Physics, forces, and mechanical effects of birth on breastfeeding. In L. J. Smith & M. Kroeger (Eds.), *Impact of birthing practices on breastfeeding* (pp. 119–145). Sudbury, MA: Jones and Bartlett.

Smith, W. L., Erenberg, A., & Nowak, A. (1988). Imaging evaluation of the human nipple during breastfeeding. *American Journal of Diseases in Childhood, 142,* 76–78.

Smith, W. L., Erenberg, A., Nowak, A., & Franken, E. A. (1985). Physiology of sucking in the normal term infant using real-time US. *Radiology, 156,* 379–381.

Snyder, J. B. (1995). Variation in infant palatal structure and breastfeeding. A project submitted in partial fulfillment of the requirements for the degree master of arts in human development specialization in lactation. Encino, CA: Lactation Institute.

Snyder, J. B. (1997). Bubble palate and failure to thrive: A case report. *Journal of Human Lactation, 13,* 139–143.

Sonies, B. C., Wang, C., & Sapper, D. J. (1996). Evaluation of normal and abnormal hyoid bone movement during swallowing by use of ultrasound duplex-Doppler imaging. *Ultrasound in Medicine and Biology, 22,* 1169–1175.

Stellwagen, L., Hubbard, E., & Vaux, K. (2004). Look for the "stuck baby" to identify congenital torticollis. *Contemporary Pediatrics, 21,* 55.

Tamura, Y., Horikawa, Y., & Yoshida, S. (1996). Coordination of tongue movements and peri-oral muscle activities during nutritive sucking. *Developmental Medicine and Child Neurology, 38,* 503–510.

Tornese, G., Ronfani, L., Pavan, C., Demarini, S., Monasta, L., & Davanzo, R. (2012). Does the LATCH score assessed in the first 24 hours after delivery predict non-exclusive breastfeeding at hospital discharge? *Breastfeeding Medicine, 7,* 423–430.

Torres, M. M., Torres, R. R. D., Rodriguez, A. M. P., & Dennis, C.-L. (2003). Translation and validation of the Breastfeeding Self-Efficacy Scale into Spanish: Data from a Puerto Rican population. *Journal of Human Lactation, 19,* 35–42.

Vice, F. L., Heinz, J. M., Giuriati, G., Hood, M., & Bosma, J. F. (1990). Cervical auscultation of suckle feeding in newborn infants. *Developmental Medicine and Child Neurology, 32,* 760–768.

Walker, M. (1989). Functional assessment of infant breastfeeding patterns. Birth, 16, 140–147.

Wall, V., & Glass, R. (2006). Mandibular asymmetry and breastfeeding problems: Experience from 11 cases. *Journal of Human Lactation, 22,* 328–334.

Wambach, K. A. (1997). Breastfeeding intention and outcome: A test of the theory of planned behavior. *Research in Nursing Health, 20,* 51–59.

Weber, F., Woolridge, M. W., & Baum, J. D. (1986). An ultrasonographic study of the organisation of sucking and swallowing by newborn infants. *Developmental Medicine and Child Neurology, 28,* 19–24.

Wiessinger, D., & Miller, M. (1995). Breastfeeding difficulties as a result of tight lingual and labial frena: A case report. *Journal of Human Lactation, 11,* 313–316.

Wilson-Clay, B., & Hoover, K. (2002). *The breastfeeding atlas* (2nd ed.). Austin, TX: LactNews Press.

Wolf, L. S., & Glass, R. P. (1992). Feeding and swallowing disorders in infancy: Assessment and management. Tucson, AZ: Therapy Skill Builders.

Woolridge, M. W. (1986). The "anatomy" of infant sucking. *Midwifery, 2,* 164–171.

Woolridge, M. (2011). The mechanisms of breastfeeding revised-new insights into how babies feed provided by a fresh ultrasound studies of breastfeeding. Abstract. 5th Europaediatrics Congress.

Woolridge, M. (2012, July). *The mechanics of infant feeding revisited: Fresh ultrasound studies of breastfeeding and bottle-feeding. Do babies extract milk from the breast using peristalsis, suction or a combination of both?* International Lactation Consultant Association conference. Orlando, Florida.

Woolridge, M., & Drewett, R. (1986). Sucking rates of human babies on the breast: A study using direct observation and intraoral pressure measurements. *Journal of Reproductive and Infant Psychology, 4,* 69–75.

Woolridge, M. W., How, T. V., Drewett, R. F., Rolfe, P., & Baum, J. D. (1982). The continuous measurement of milk intake at a feed in breastfed babies. *Early Human Development, 6,* 365–373.