CHAPTER

1

Breastfeeding: Normal Sucking and Swallowing

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Normal Sucking

All mammals share a neurobehavioral program for sucking. They are competent to get to the teat—without maternal assistance—attach to it, and transfer milk. Humans are no exception. When born without labor medications and placed immediately on the mother's abdomen, a human infant goes through a predictable behavioral sequence, leading to breastfeeding (Ransjö-Arvidson et al., 2001; Widström et al., 2011). See **Box 1-1 and Box 1-2**.

Labor medications and separation from the mother disrupt this sequence and can lead to incorrect sucking patterns (Righard & Alade, 1990). A later return to skin-to-skin contact can re-establish the original behavioral sequence and allow the infant to learn to attach (see Chapter 4).

When an infant is seen as incompetent, adults exert control, which can interfere with infant instinctive behaviors (Schafer & Genna, 2015). It is helpful to understand the triggers that stimulate feeding-related reflexes and responses in order to assist breastfeeding families without disempowering them.

Box 1-1 Ransjö-Arvidson et al. Behavioral Sequence

1. Hand to mouth movements
2. Tongue movements
3. Mouth opening
4. Focusing on the nipple
5. Crawling to the nipple
6. Massaging the breast to evert the nipple
7. Licking
8. Attaching to the breast

Data from Ransjö-Arvidson, A.-B., Matthiesen, A.-S., Lilja, G., Nissen, E., Widström, A. M., & Uvnäs-Moberg, K. (2001). Maternal analgesia during labor disturbs newborn behavior: Effects on breastfeeding, temperature, and crying. *Birth, 28*(1), 5–12.

Box 1-2 Widström et al. Behavioral Sequence

1. Birth Cry
2. Relaxation
3. Awakening
4. Activity
5. Crawling
6. Resting
7. Familiarization
8. Suckling
9. Sleeping

Data from Widström, A. M., Lilja, G., Aaltomaa-Michalias, P., Dahllöf, A., Lintula, M., & Nissen, E. (2011). Newborn behaviour to locate the breast when skin-to-skin: A possible method for enabling early self-regulation. *Acta Paediatrica*, *100*(1), 79–85.

Human infants are most competent when skin-to-skin contact with their mothers begins immediately after birth without separation. A newborn may stop and rest several times between bursts of activity, and then resume. This can easily be mistaken as stalling and can stimulate well-meant interference. Infants suck their hands as part of the activity and familiarization phases. Hand-to-breast-to-mouth movements seem to be essential to the latch process: the more of these movements a newborn makes, the faster they grasp the breast and begin suckling (Widström et al., 2011).

Human infants expect positional stability; complete prone positioning against the mother's abdomen or chest allows the infant better neck control and refined jaw and tongue movements. The gravitational input from being prone on a semi-reclined mother optimizes feeding-related reflex behaviors, facilitating latch and breastfeeding (Colson, Meek, & Hawdon, 2008). When infants self-attach, they scan the mother's chest with their cheeks and move toward the breast. Once the breast is identified, the infant extends their neck and leads with their chin. When the chin contacts the breast, the infant starts seeking the nipple. In addition to touch stimuli, infants use their sense of smell (Porter & Winberg, 1999). The Montgomery glands secrete an odor that attracts the infant, induces a state more conducive to breastfeeding, and stimulates pre-feeding behaviors (Doucet, Soussignan, Sagot, & Schaal, 2009). The areola warms to better diffuse the volatile compounds secreted by these glands when the mother hears the infant's birth cry (Zanardo & Straface, 2015).

The number of Montgomery glands on the areola is associated with early weight gain in the breastfeeding infant and the onset of copious milk secretion in primiparas (Doucet, Soussignan, Sagot, & Schaal, 2012).

When the nipple contacts the philtrum (the ridge between the nose and upper lip), the infant gapes widely and grasps the nipple and the surrounding tissue with the tongue, seals to the breast, and begins to suck. An infant who has difficulty locating the nipple with the face or mouth may use their hands to assist in the search (Genna & Barak, 2010).

One can use these expectations to assist babies who have difficulty latching on. The infant helplessness model leads mothers to try to do too much for the baby, and many mothers handle their breast like a bottle, trying to center the nipple in the baby's mouth. Healthy, neurotypical infants simply need stability against the mother's body and tactile proximity to the breast, preferably so the nipple is at the philtrum and the chin is on the breast, and the infants are able to open their mouth well, bring the tongue down, lunge forward, and grasp the breast. When infants are unable to self-attach, special techniques can be used to assist them. These are covered in Chapter 5.

Although a neurobehavioral program guides the initial attachment and sucking experiences, rapid learning occurs. Human infants are able to experiment with different sucking pressures and different lip, tongue, and jaw movements to maximize the amount of milk they obtain or to reduce an uncomfortably fast flow. Some of these compensations will be adaptive for the infant and comfortable for the mother, but some will not and will require intervention. This book focuses on interventions that have proven helpful in practice.

In order to intervene in any process, it is important that normal be well understood. Ideally, the infant orients to the nipple (rooting response), opens the mouth widely (gape response), and brings the tongue down to the floor of the mouth (tongue depression) and extends it over the lower lip to grasp the breast. As the mouth closes, the anterior tongue grooves to form a teat from the nipple and surrounding breast. The teat is enclosed between the grooved tongue, cheeks, and palate. The nipple is as far back in the mouth as possible, generally to the posterior hard palate (Jacobs, Dickinson, Hart, Doherty, & Faulkner, 2007).

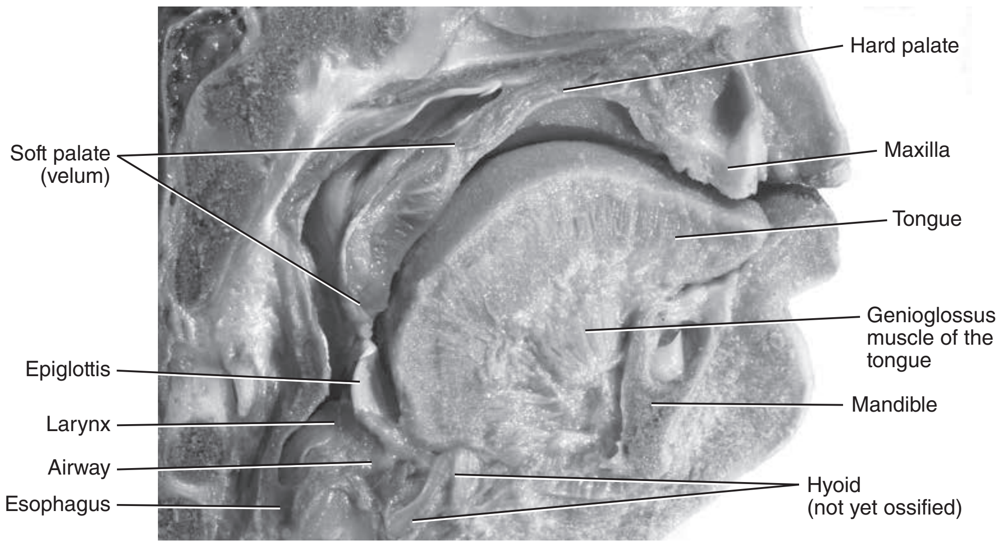
After attachment, the infant holds the breast with the anterior tongue, and the lips assist with sealing the mouth against the breast. The soft palate hinges downward and presses against the back of the tongue. The soft palate, grooved tongue, lips, and cheeks make a sealed chamber around the nipple. The anterior tongue follows the mandible as it lowers in the beginning of a suck. The posterior tongue then moves downward in a wavelike movement from the front of the mouth to the back, to maximize intraoral space (Elad et al., 2014). The enlargement of the sealed oral cavity produces negative (suction) pressure (Geddes, Kent, Mitoulas, & Hartmann, 2008). Once the milk ejection reflex is triggered, milk sprays from the nipple and gathers in a small pool, or bolus, on the grooved or bowl-shaped tongue. The mandible then elevates, bringing the anterior tongue along, and then the wave of upward movement travels along the posterior tongue to push the bolus into the pharynx. The soft palate elevates, and the pharyngeal walls contract to meet it in order to close off the nasopharynx, or nasal air space. The suprahyoid muscles pull the hyoid bone and with it the larynx anteriorly to shorten the pharynx. The arytenoid cartilages approximate (move together) to close the vocal folds to protect the airway. Milk is directed around the epiglottis and away from the airway laterally. The tongue creates positive pressure to push the bolus of milk into the pharynx, where wavelike contractions of the pharyngeal constrictor muscles move the bolus to the opening of the esophagus, called the upper esophageal sphincter (also called the pharyngoesophageal segment), where the cricopharyngeous muscle relaxes and allows entry of the bolus (Arvedson, 2006; Kennedy et al., 2010).

Anatomy

The newborn human mouth is particularly well designed for sucking (**Figure 1-1**). The tongue is large in relation to the size of the oral cavity. When the mouth is open, the tongue and breast fill it completely, providing stability to the tongue and jaw movements. The normal resting position of the tongue is with the tip over the lower lip, where it can easily contact the breast.

The cheeks contain fat pads that add to the thickness of the cheek wall and help guard against collapse of the cheeks when the oral cavity is enlarged by tongue depression (**Figure 1-2**). If the cheeks collapse, the oral cavity becomes smaller and the negative pressure decreases. Ultrasound studies have demonstrated that the negative pressure in the mouth is vital to milk transfer (Ramsay & Hartmann, 2005) and that milk flows from the breast when the posterior tongue is down and the suction pressure is highest (Geddes, Kent et al., 2008). The fat pads of the cheeks also provide lateral (side) borders to support the tongue in a grooved position and keep it in midline during sucking. Although newborns can perform lateral (side-to-side) tongue movements, these are generally not used during feeding until solids are begun after 6 months of age. The *buccinator* muscles compress the cheeks when activated to maintain contact between the cheek and breast during breastfeeding. In older children, when fat pads disappear, these muscles help to keep food in contact with the teeth during chewing. The buccinators are innervated by the facial nerve (CN VII) (Arvedson, 2006).

The lips are soft and flexible, and the lower lip is generally flanged outward on the breast, allowing contact with the soft mucous membrane. The upper lip is usually in a more neutral position when attachment is correct. (An overly turned-out upper lip is a sign of a shallow latch and can favor excessive use of the lips to press milk out of the breast.) Around the outside of the



Courtesy of Brian Palmer, DDS

Figure 1-1 Midsagittal section, oral anatomy of a 7-month fetus.

soft lips is a complex circular muscle made up of many fibers, named the *orbicularis oris*. Partial contraction of this muscle helps maintain the lips' seal on the breast. The mentalis muscle at the base of the lower lip elevates and protrudes the lip, and it is very active during breastfeeding. These muscles are innervated by the facial nerve (CN VII). The mandible (lower jaw) is usually short in newborns, perhaps due to mechanical restriction of chin growth from being positioned against the chest in utero. The infant's predominant flexor muscle-tone pattern, which favors jaw opening over closing, may help compensate for the short mandible. Poor grading of movement (fine control over the speed and amount) also favors a large gape. The masseter muscle on the outside of the jaw and the medial pterygoid on the inner side relax to depress the mandible, and they contract to elevate the mandible during sucking.

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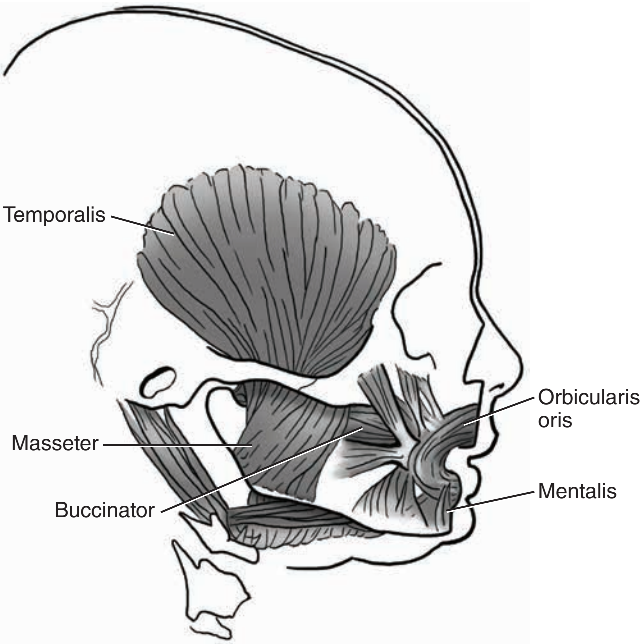
Figure 1-2 Buccal fat pads provide lateral stability to the tongue in newborns.

Both sides working together allow symmetrical jaw movement during sucking; unilateral action of the masseter and lateral pterygoid causes the sideways jaw movements of chewing. The temporalis muscle closes the mandible during sucking. The fibers of the muscles of mastication (chewing) are more similar to cardiac muscle than to normal skeletal muscle, allowing for faster functioning and less fatigue (Korfage, Koolstra, Langenbach, & van Eijden, 2005a, 2005b). These muscles of mastication are innervated by the trigeminal (CN V) nerve's third (mandibular) branch.

Tongue and jaw motions are linked through mutual attachments to the hyoid bone to make it easier for the infant to use the tongue and jaw in concert during sucking. The mandible raises to help generate positive pressure during swallowing, and the mandible drops during suction (negative pressure). Suprahyoid muscles are important during sucking, particularly the mylohyoid and anterior belly of the digastric muscle (Ratnovsky et al., 2012). These muscles are activated when the tongue drops. They pull the mandible down and the hyoid up, intensifying suction pressure. These actions help to provide the power movements for sucking and raise the hyoid for safer swallowing. The electromyographic activity of the suprahyoid muscles during breastfeeding increases from birth to 3 months, after which it levels out (Tamura, Matsushita, Shinoda, & Yoshida, 1998). Increasing strength of these muscles may be partially responsible for the apparent increase in breastfeeding efficiency over the first 3 months of life, and reflects the maturation of postural control of the head and neck.

The tongue is a complex structure made of interdigitated muscle layers. In the past, a greater distinction was made between extrinsic and intrinsic tongue muscles, but careful dissections using advanced staining techniques have revealed that fibers from muscles that were thought to arise outside the tongue become incorporated into the body of the tongue (Hiiemae & Palmer, 2003; Takemoto, 2001). It is helpful to think of intrinsic muscles as changing the shape of the tongue and extrinsic muscles as connecting the tongue to other structures to help it move in concert with those structures (such as the soft palate and hyoid).



Courtesy of Peter Mohrbacher

Figure 1-3 Facial muscles involved in feeding.

The intrinsic muscles of the tongue include the genioglossus, which pulls the tongue down during the negative pressure phase of sucking; the superior longitudinal muscles, which lift the tongue tip; the inferior longitudinals, which lower the tongue tip and help move it from side to side; the vertical muscles, which help thin the tongue; and the transverse muscles, which, along with the genioglossus and the extrinsic muscles, help to groove the tongue (**Figure 1-3**). Most of the fibers of the intrinsic tongue muscles are fast responding, allowing rapid changes in tongue configuration (Stal, Marklund, Thornell, De Paul, & Eriksson, 2003). The extrinsic muscles include the palatoglossus, which helps elevate the back of the tongue and brings the soft palate down to seal the back of the mouth; the styloglossus, which helps pull the tongue up and back; and the hyoglossus, which retracts and pulls the tongue down low in the mouth. All the tongue muscles except the palatoglossus are innervated by the hypoglossal nerve (CN XII); the palatoglossus is innervated by the vagus nerve (CN X). An understanding of the arrangement and relationships of the tongue muscles allows facilitation of correct sucking in infants with difficulties. See **Plate 8** for a three-dimensional representation of the arrangement of the muscles of the tongue, courtesy of Hironori Takemoto, PhD.

In humans, the airway and food passages cross, creating a *biological timeshare* (Cichero, 2007). Air passes from the nasopharynx through the pharynx and into the larynx through the vocal folds to the trachea, bronchi, and lungs. Food passes from the oropharynx through the pharynx, around the epiglottis, and to the esophagus. To reduce passage of air to the stomach, the cricopharyngeus muscle remains contracted to close the top of the esophagus unless a swallow is occurring. To keep food out of the airway, the true and false vocal folds close. The muscles of the airway and food passages are innervated by the vagus nerve (CN X).

Newborns have unique anatomical airway protection to help compensate for their immature laryngeal closure. At birth, the hyoid bone is still cartilage and not yet mineralized. The larynx is high, reducing the amount of space the bolus needs to travel. The epiglottis is high and elongated; it touches or overlaps the soft palate at rest, and the upper airway is very short.

This helps to direct milk around the airway to the esophagus and reduces the risk of aspiration. This airway configuration also encourages the infant to extend the neck, which reduces resistance to airflow in the airway and brings the small mandible forward to have as much contact with the breast as possible. Tongue and mandible contact with the breast needs to be as complete as possible for proper mechanical advantage during sucking.

Suckling or Sucking: Differences Between Suckling at the Breast and Sucking at the Bottle

Older literature on feeding posits that suckling (the front-to-back, wavelike movement of the tongue) changes to sucking (a straight up-and-down movement of the tongue and jaw) at around 3 months of age. A Japanese study of sucking patterns during bottle feeding (Iwayama & Eishima, 1997) of previously breastfed and bottle-fed infant showed a transition to a sucking pattern in infants older than age 3 months, but this might have been due to mechanical differences between breast and bottle or the growth of the oral cavity in relation to the static artificial nipple. Electromyography (EMG) studies have confirmed that muscle activation is different between breastfeeding and bottle feeding, with less use of the mentalis and masseter muscles and more use of the buccinator and orbicularis oris muscles in bottle feeding (Gomes, Trezza, Murade, & Padovani, 2006; Inoue, Sakashita, & Kamegai, 1995; Nyqvist, 2001). Lactation consultants have long been skeptical of the idea that there are two age-dependent forms of sucking at the breast. Our ultrasound suck research has shown that breastfeeding children up to 4 years old use the same sucking pattern reported by Elad and colleagues (2014); Geddes, Kent et al. (2008); and Miller and Kang (2007). For this reason, the term *suckling* shall be used to mean the act of feeding at the breast, and the term *sucking* will be used to describe the oral motor activity that transfers milk, with the understanding that breastfeeding is the biological norm for human beings and normal sucking is the sucking that occurs at the breast.

Deglutition (Swallowing)

For professionals working with children who have feeding issues, there are two terms that are useful to understand: feeding and swallowing. *Feeding* refers to what takes place during the *oral phase*, from sucking up to bolus formation, and then propelling the bolus posteriorly in the mouth. In contrast, *swallowing* encompasses all three phases: the oral, pharyngeal, and esophageal phases from when the milk enters the mouth until it enters the stomach. The primary focus of the lactation consultant is to assess the feeding aspects (the oral phase); however, it is important to understand the entire process and how posture and positioning affect swallowing. Generally, evaluation of the pharyngeal and esophageal phases is carried out through instrumental tests, such as the videofluoroscopic swallow study (VFSS), also known as the modified barium swallow study (MBS). The fiberoptic endoscopic evaluation of swallowing (FEES) is used to evaluate the pharyngeal phase. Both will be discussed later in this chapter. **Figure 1-4** shows the appearance of the upper digestive tract of an older infant on a VFSS. Tests are typically ordered by a physician and performed and interpreted by radiologists and speech–language pathologists or occupational therapists.

The anatomical structures used for feeding are also used for breathing and speech production. An infant is faced with the challenge of using these structures in a highly orchestrated way

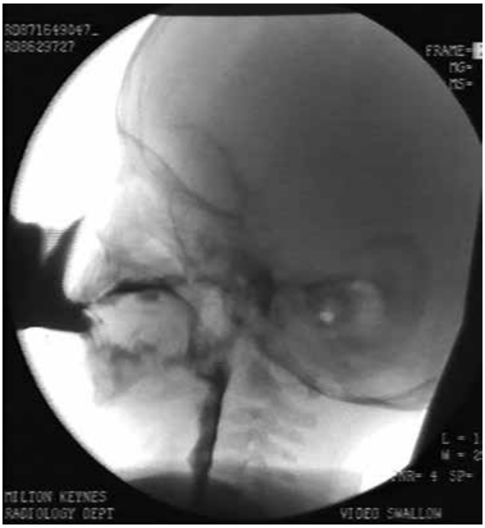


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Figure 1-4 VFSS of a toddler drinking from a sippy cup. The dark liquid outlines the path milk takes during swallowing.

in order to maintain oxygenation and acquire adequate intake to grow. Sucking is the initial stage of a three-part swallowing process (Martin-Harris, 2015; Averdson & Brodsky, 2002; Miller, 1999). Swallowing has three phases that must take place in a synchronous, organized fashion for safe feeding to occur.

Although both sucking and swallowing occur prenatally, they do not necessarily occur together. In utero, swallowing is observed in fetuses as early as 12.5 weeks' gestation, but sucking with patterned tongue movements does not seem to appear until 26 weeks. Color Doppler sonography reveals amniotic fluid flow consistent with mature swallow in some fetuses starting at 29 weeks' gestation and in a larger proportion by 37–38 weeks (Grassi, Farina, Floriani, Amodio, & Romano, 2005; Miller, Sonies, & Macedonia, 2003). A full-term fetus swallows 450 mL of amniotic fluid in a day (Bosma, 1986). This volume is greater than early postnatal daily intake. The discrepancy may be due to the need for the neonate to coordinate sucking, swallowing, and breathing. The high viscosity and low volume of colostrum make it a safer food for an inexperienced newborn, and the fact that it is less fluid than the infant is accustomed to may increase motivation to breastfeed often and stimulate maternal milk production. Indeed, earlier breastfeeding initiation (Bystrova et al., 2007; Nakao, Moji, Honda, & Oishi, 2008), more frequent breastfeeding (Chen, Nommsen-Rivers, Dewey, & Lonnerdal, 1998; Bystrova et al., 2007), and more efficient milk removal (Morton et al., 2009) in the first days of life lead to increased milk production weeks later, and indeed for the entire course of lactation. Conversely, birth interventions, high maternal body mass index (BMI), and mother–infant separation also delay copious milk production and reduce colostrum and milk intake (Chantry, Nommsen-Rivers, Peerson, Cohen, & Dewey, 2011; Matias, Nommsen-Rivers, Creed-Kanashiro, & Dewey, 2010; Nommsen-Rivers, Chantry, Peerson, Cohen, & Dewey, 2010). See Chapter 3 for more information.

Healthy human infants rapidly improve their coordination of swallowing and breathing over the first few days (Weber, Woolridge, & Baum, 1986) and weeks of life, even when held in awkward (supine) positions for breastfeeding to allow comparison with bottle-fed infants (Kelly, Huckabee, Jones, & Frampton, 2007; Weber et al., 1986). Babies have lower heart rates and longer sucking bursts while breastfeeding at 2–4 months old than they do in the neonatal period ($<$ 1 month), indicating better coordination and perhaps conditioning of the cardiorespiratory system (Sakalidis et al., 2013). With increasing age, newborns are more likely to breathe out right after swallowing during breastfeeding than bottle feeding (Kelly et al., 2007), which provides another layer of protection against aspiration. Older infants who are breastfeeding and growing normally swallow with each suck cycle during the mother's milk ejection (Geddes, Chadwick, Kent, Garbin, & Hartmann, 2010) and vary the location of the swallow in the respiratory cycle

Box 1-3 Central Pattern Generators for Swallowing

Imagine you need to press 25 buttons with each hand in a specific order in about a half-second. Swallowing uses 25 pairs of muscles that need to activate rapidly and sequentially to protect the airway and send the bolus down to the stomach, while closing off breathing for the shortest possible time. Instead of pressing all the buttons manually, you use a machine that will press the buttons to activate each muscle for you. If you want to be really elegant, you can create one machine for each hand, and a second pair of machines that modify the timing between button presses and how hard each button is pushed, to allow for changes in the amount or kind of food swallowed. This is exactly the arrangement in the human brainstem. The dorsal swallowing groups set the pattern—the order in which the buttons are pushed—and the ventral groups do the pushing (distributing signals to motor neurons). Both receive modulating signals from the rest of the brain to tell them what is being swallowed and how much, so they can vary their timing and intensity to get the job done.

(Geddes, personal communication, July 2008). This may allow more flexibility in meeting their needs for food and oxygen than a constrained pattern of suck–swallow–breathe behavior would.

Neural Control of Sucking and Swallowing

Sucking, swallowing, breathing, walking, and many other patterned, sequential movements are directed by central pattern generators (CPGs) located in the brainstem and spinal cord (**Box 1-3**). The CPG is made up of networks of interneurons that communicate with brainstem or spinal cord motor nuclei to direct the sequencing of the motor activity (Grillner, 1991, 2002; Barlow & Estep, 2006). Interneurons connect different brain centers, as opposed to afferent (incoming, sensory) and efferent (outgoing, motor) neurons that transmit signals between the brain and body.

Interneurons allow sensory or other state information to be shared in the brain and allow for coordination of output signals. The human CPG for swallowing is complex, allowing maximum control and response to changes in bolus consistency, size, and flow characteristics. Taste, temperature, and touch receptors in the face, mouth, pharynx, larynx, and esophagus send information through the sensory branches of cranial nerves (CN V, VII, XII, and X) to the primary sensory relay in the brainstem (Jean, 2001; Miller, 1999). Neurotransmitters send messages via interneurons with the motor nuclei for cranial nerves (CN V, IX, X, and XII) located in the brainstem and spinal cord. Motor nuclei innervate and direct the muscles and end organs to carry out patterned, sequential movements for swallowing. Interneurons and motor nuclei for the respiratory CPG are located in close proximity to the swallowing CPG (Jean, 2001; Miller, 1999), facilitating the coordination of swallowing and breathing.

Sucking and swallowing begin as primitive rhythmic motor movements. The motor movements of the CPG are modulated by sensory feedback from the structures involved in the movements and by cortical structures. The CPG neuronal networks are modified and new motor patterns evolve as the infant experiences new and varied sensory input and increasing feeding challenges. The cortex plays a role in eventually suppressing primitive reflexes (e.g., rooting) as more-refined feeding behaviors develop in preparation for ingesting solid food (Altschuler, 2001; Barlow & Estep, 2006; Grillner, 2003, 1991; Kelly et al., 2007; Stevenson & Allaire, 1991). Functional magnetic resonance imaging (MRI) studies of brain activation during voluntary swallows in adults have shown that brain regions involved in controlling the swallow include the somatosensory and motor cortex areas, the cerebellum, thalamus, putamen, cingulate gyrus, and insula (Cichero & Murdoch, 2006; Malandraki, Sutton, Perlman, Karampinos, & Conway, 2009). Since so many brain areas need to work together in swallowing, infants with neurological deficits have a higher likelihood of swallowing abnormalities (dysphagia).

For example, if a mother is returning to employment outside the home, she may introduce a bottle to her exclusively breastfed infant once or twice per week in preparation. The baby must learn the new motor pattern for sucking with an artificial nipple from a receptacle (bottle), which provides different sensory input in the form of texture, flexibility, method of milk removal, flow rate, etc., compared to the mother's nipple and breast (mammary gland). Many babies are able to adapt to these sensory changes in this situation. Sensation provides input for the purpose of altering motor movements and allows the infant to adapt to physical changes in the environment, such as a new feeding implement that does not function like a secretory gland.

Some babies have difficulty adapting to these changes, resulting in difficulty sucking from a bottle or difficulty transitioning back to the breast when a bottle has been given. Health, environmental, or social stressors can all impact the baby's adaptability.

Reflexive Control of Sucking and Swallowing

As previously stated, the newborn infant depends primarily on reflexes for feeding. Reflexes are prewired templates for life-sustaining movements in the infant that gradually become integrated into voluntary movement patterns (**Table 1-1**) or become inhibited by higher brain centers as these mature.

The *rooting* response is a reflex group that is stimulated by touch to the face and mouth. It causes the infant to turn toward the breast, open the mouth (gape response), depress and extend the tongue, and grasp the breast.

The *transverse tongue* reflex occurs when the lateral edge of the tongue is stroked. The infant's tongue should move toward the source of stimulation. *Tongue protrusion* occurs when the anterior tongue is touched. The *phasic bite* reflex is not elicited during sucking unless the infant retracts the tongue and exposes the gum ridge to stimulation. These reflexes diminish by around age 6 months in preparation for the introduction of solid foods.

Like sucking, *swallowing* is not a simple reflex; it encompasses complex, highly orchestrated sensory and motor events that are under both voluntary and involuntary control (Arvedson & Brodsky, 2002).

The *cough* reflex is of great importance to feeding because it allows the infant to expel material that has entered the airway and/or has been aspirated. This protective reflex is triggered by sensory receptors (chemoreceptors) in the larynx, causing a temporary cessation of breathing constriction of the airway, and a cough to propel the foreign material out of the airway (Arvedson & Lefton-Greif, 1998). In preterm infants, the laryngeal chemoreflex is not as

Table 1-1 Oral–Motor, Cranial Nerve, and Reflex Evaluation

Reflex	Stimulus	Behavior	Cranial Nerves Involved	Present At
Protective Reflexes				
Cough	Fluid in larynx or bronchi	Upward movement of air to clear the airway	X Vagus	*40 weeks' gestation
Gag	Touch back of tongue	Mouth opening, head extension, floor of mouth depresses	IX Glossopharyngeal X Vagus cortex	26–27 weeks' gestation
Adaptive Reflexes				
Phasic bite	Stimulate gums	Rhythmic up and down jaw movement	V Trigeminal	28 weeks' gestation
Transverse tongue	Stroke sides of tongue	Tongue moves toward side of stimulus (lateralizes)	XII Hypoglossal	28 weeks' gestation
Tongue protrusion	Touch tongue tip	Tongue protrudes from mouth	XII Hypoglossal	38–40 weeks' gestation
Rooting	Stroke cheek or near mouth	Infant senses stimuli and localizes toward source, opens mouth (gapes), extends and depresses tongue to grasp breast, creates seal against breast	V Trigeminal VII Facial XI Accessory XII Hypoglossal	28 weeks' gestation
Sucking	Touch to junction of hard/soft palate	Wavelike tongue movement coordinated with up-and-down jaw movement	V Trigeminal VII Facial IX Glossopharyngeal XII Hypoglossal	27–28 weeks' gestation

*Thach 2001, 2007.
Data from Hall, K. D. (2001). *Pediatric dysphagia resource guide*. San Diego, CA: Singular.

mature, and the infant may experience the apnea component (to avoid breathing in the fluid that has penetrated the larynx) and bradycardia (slow heart rate) but not cough to expel the fluid. Since normal breathing does not resume until after the cough clears the airway, preterm infants are at risk of stopping breathing if they fail to swallow safely. As vagus myelination improves with maturity and feeding experience, these issues resolve (Becker, Zhang, & Pereyra, 1993; Newman, 1996).

The *gag* reflex is the other protective reflex that prevents the infant from swallowing a solid object or a bolus larger than the pharynx can handle.

The Three Phases of Swallowing

In order to develop an understanding of the three phases of the swallow, a listing of the phases and the structures involved in each phase are as follows (Martin-Harris, 2015; Arvedson & Brodsky, 2002; Miller, 1999):

Oral Phase:

- Lips
- Tongue/mandible
- Cheeks
- Hard palate

Pharyngeal Phase:

- Soft palate (velum)
- Pharyngeal muscles surrounding the throat
- Epiglottis
- Laryngeal muscles
- Arytenoid mass (made up of the false vocal folds, true vocal folds, and arytenoid cartilages; the arytenoid cartilages sit on top of the true vocal folds posteriorly, and they open the airway during breathing and close the airway during swallowing)
- Pharyngoesophageal segment (PES), also called the upper esophageal sphincter (UES), which includes the cricopharyngeous muscle

Esophageal Phase:

Esophagus, made up of longitudinal and circular muscles which help to move the bolus toward stomach

How the Three Stages of Swallowing Work

Oral Phase

Rooting, attachment, and sucking comprise the beginning of the oral phase. During sucking, the tongue forms a central trough or groove for channeling the milk posteriorly. The lateral

Box 1-4 Is It Tongue Stripping (Positive Pressure) or Suction (Negative Pressure) That Removes Milk?

Studies have described infants as using a stripping, wavelike tongue motion that proceeded from the front of the mouth backward (Bosma, Hepburn, Josell, & Baker, 1990; Hayashi, Hoashi, & Nara, 1997; Newman, 1996; Weber et al., 1986; Monaci & Woolridge, 2011; Burton, Deng, McDonald, & Fewtrell, 2013) during feeding. These wavelike movements were only seen if the ultrasound transducer was aligned in the exact midline of the infant's tongue (Burton et al., 2013). Multiple groups have confirmed that milk is visualized flowing into the infant's mouth when the tongue is down and the nipple is maximally expanded, which indicates that subatmospheric (negative) pressure is responsible for milk flow (Elad et al., 2014; Geddes, Kent et al., 2008; Ramsay & Hartmann, 2005). Wavelike tongue movements are vital to allow the back of the tongue to fully drop in the mouth, creating maximal space and therefore minimal pressure in the mouth. Infants who create excessive vacuums in the mouth but have restricted tongue range of motion transfer less milk, possibly by impeding nipple expansion and opening of the nipple pores to allow milk flow (McClellan, Kent, Hepworth, Hartmann, & Geddes, 2015). Wavelike tongue movements are even more important for swallowing. As the peristaltic-like wave travels along the tongue from front to back, it pushes the bolus of milk into the pharynx (Elad et al., 2014). This provides positive pressure to initiate a strong, safe swallow.

edges of the tongue seal to the palate to keep the bolus organized (Cichero & Murdoch, 2006; Yang, Loveday, Metreweli, & Sullivan, 1997). Milk is delivered onto the tongue as the back of the tongue drops to create negative pressure in the mouth. Wavelike mechanical movements and pressure changes (positive pressure) created by the tongue propel the bolus to the back of the oral cavity (**Box 1-4**).

Pharyngeal Phase

In newborns, the presence of the bolus at the valleculae at the base of the tongue triggers the swallow. The following mechanisms for protection of the airway are engaged (Arvedson 2006; Arvedson & Brodsky, 2002; Mendell & Logemann, 2007; Moriniere, Boiron, Alison, Makris, & Beutter, 2008):

1. Breathing stops.
2. The soft palate (velum) elevates to close off the nasal cavity and prevent the bolus from going into the nose (nasopharyngeal reflux), and the outer layer of pharyngeal muscles contract to shorten the pharynx.
3. The true and false vocal folds (cords) come together to close over the trachea.
4. The hyoid moves anteriorly.
5. The larynx (suspended from the hyoid by muscles and cartilage) moves anteriorly under the epiglottis and the base of the tongue. The epiglottis is lifted and tipped slightly backward by this same movement and the pharynx is shortened. This same

Box 1-5 What Is Peristalsis?

Peristalsis is defined as progressive contraction down a muscular tube. This is the activity seen in the esophagus as the bolus is progressively moved toward the stomach by both longitudinal and wavelike contractions of the muscles. Logemann (1998) points out that it is inaccurate to use this term in reference to the movement of the bolus in the oral and pharyngeal phases of the swallow because anatomically they are not muscular tubes. Rather, there are pressure changes propelling the bolus. This can be seen by the rolling wave of the tongue in the oral cavity creating positive pressure, which moves the bolus over the base of the tongue (Logemann, 1998). Therefore, the term *peristalsis* will be used in this text to describe what occurs in the esophageal phase, and tongue movements involved in swallowing will be described as *wavelike* or *peristaltic-like*. It is important that the pharyngeal phase of the swallow be well coordinated because this is the phase during which there is the greatest risk of aspiration. The infant's ability to propel the bolus to the tongue base (valleculae) is important for setting the pharyngeal phase in motion and signaling the onset of the cascade of movements that protect the airway and direct the bolus to the esophagus (Arvedson & Brodsky, 2002).

upward movement also assists in opening the upper esophageal sphincter (pharyngoesophageal segment).

6. The tongue moves the bolus posteriorly, pushing against the posterior pharyngeal wall forcefully to create positive pressure. The epiglottis tips back toward the pharyngeal wall to divert the bolus laterally away from the larynx and airway. The muscles of the pharyngeal wall shorten the length of the pharynx and create a squeezing wavelike effect to quickly move the bolus to the esophagus.
7. The upper esophageal sphincter opens, and the bolus enters the esophagus to make its way to the stomach.

Esophageal Phase

The bolus moves through the esophagus (food tube) toward the stomach, consisting of the following stages:

1. Peristaltic movement of the bolus through the esophagus (**Box 1-5**)
2. Opening of the lower esophageal sphincter to allow the bolus to enter the stomach (The LES normally keeps the contents of the stomach from moving retrograde into the esophagus.)

Dysphagia

Dysphagia, or swallowing disorder, can range from mild to severe. The feeding specialist, a speech–language pathologist or occupational therapist, sometimes in cooperation with a specialist physician, assesses the swallowing mechanism during the oral, pharyngeal, and esophageal phases if dysphagia is suspected. Signs that an infant might be swallowing incorrectly include frequent coughing or choking, distress during feeding or refusal to feed, congestion or a wet quality to the voice or breathing—especially if it gets worse as a feeding progresses—palpable rumbling in the infant's chest during breathing, and frequent vomiting during or after feedings.

Breastfed infants rarely have the recurrent respiratory infections that are typical of formula aspiration. A clinical examination involves observing oral movements in isolation and while the infant is feeding. The feeding specialist looks at the quality of feeding movements, listens to swallowing sounds (**Box 1-6**), observes for changes in the infant's respiratory pattern and color, and may try positioning changes to improve the infant's swallowing. If a swallowing problem is suspected, instrumental procedures are carried out to identify the source of the swallowing disorder, which phase or phases are disrupted, and useful therapy techniques. **Table 1-2** shows the evaluation procedures that are used to identify dysphagia. For a more extensive discussion of these instrumental procedures, refer to Arvedson and Brodsky (2002).

Box 1-6 Cervical Auscultation

Listening over the neck or under the chin with a stethoscope is an easy, useful way for lactation consultants to scrutinize swallowing sounds. Normal swallowing sounds like a crisp, rapid biphasic click—cuh-LIK (Vice, Bamford, Heinz, & Bosma, 1995; Vice, Heinz, Giuriati, Hood, & Bosma, 1990). Wet, bubbling sounds can indicate air passing through an incompletely cleared pharynx (Bosma, 1986), and short, discrete bouts of stridor during the swallow can indicate that fluid has leaked into the larynx (laryngeal penetration) and the vocal folds have closed rapidly to keep it out. In addition, delayed initiation of the swallow, inefficient swallowing (multiple swallows needed to clear the pharynx), and slower than normal swallowing (a drawn-out click that indicates a small bolus) can be identified (Cichero & Murdoch, 2002). The integration of swallowing and breathing can clearly be heard because inspiration and expiration each have characteristic sounds. Feeding-induced apnea or breath-holding (several swallows without an intervening breath) become obvious, as do stressed swallows, which sound like gulps. Infants with clinical symptoms of dysphagia (repeated respiratory infections; congested, wet breathing sounds; feeding refusal) that do not resolve with management changes (prone feeding to assist bolus handling, applying pressure on the breast near the areola to obstruct some ducts during rapid milk flow, feeding from a partially pumped breast, treatment of tongue-tie if indicated, calibration of milk supply to meet infant need if hyperlactation is responsible) should be referred for instrumental studies to determine whether oral feeding is safe. Exclusively breastfed infants rarely have repeated respiratory infections even if they are aspirating because human milk is less irritating to the human respiratory epithelium than other foods. In this case, breastfeeding with interventions to improve handling of flow can continue, but caution is warranted when weaning begins (feeding any liquid or food other than human milk).

Table 1-2 Instrumental Procedures for Identifying Dysphagia

Instrumental Procedure	Parts of Swallow Studied
Upper gastrointestinal study (upper GI)	Esophagus, stomach, duodenum
Videofluoroscopic swallow study (VFSS), also called modified barium swallow study (MBS)	Oral, pharyngeal, and upper esophageal phases of swallowing. Clinician can identify type and severity of swallowing impairment, identify occurrence of laryngeal penetration/aspiration, and explore usefulness of treatment strategies.
Ultrasound	Oral phase of swallowing
Cervical auscultation (CA)	Sounds of breathing and swallowing in pharyngeal phase
Fiberoptic endoscopic evaluation of swallowing (FEES)	Direct view of pharyngeal and laryngeal structures. Clinician evaluates pharyngeal swallow. Remains of bolus can be seen if present. Treatment strategies can be trialed for usefulness.

The videofluoroscopic study (VFSS) has been widely used because it provides the clinician with assessment information regarding where the swallowing issue is occurring—the oral, pharyngeal, and/or esophageal phases—and whether there is penetration or aspiration in the airway. Inferences can be made regarding weakness of the muscles, decreased sensation, etc. Based on this information, the clinician can select treatment strategies and determine their effectiveness during the procedure. Over the past 10 years, speech–language pathologists working with infants and children (Gosa, Suiter, & Kahane, 2015; Weckmueller, Easterling, & Arvedson, 2011), as well as adults (Martin-Harris, 2015; Martin-Harris & Jones, 2008; Martin-Harris et al., 2008) have been gathering data and developing evidence-based methods to standardize the VFSS procedure.

VFSS is not typically performed with infants breastfeeding, but rather bottle feeding. Clinicians must be aware that when presented with an unfamiliar feeding method, an infant's feeding performance may or may not be representative of typical breastfeedings.

Another instrumental examination that has been used increasingly is the fiberoptic endoscopic evaluation of swallowing (FEES). A fiberoptic camera is passed through one of the nares and into the pharynx in order to observe the structures of the pharynx and larynx at rest, during phonation (sound production), and during the pharyngeal swallow. It has the benefit of not exposing the infant to radiation since it does not involve X-rays. Therapeutic strategies can be trialed during this technique as well. Willette, Molinaro, Thompson, and Schroeder (2015) reported that FEES can be safely used to evaluate a baby's swallowing function while breastfeeding with the mother using familiar breastfeeding positions. Treatment maneuvers can then be trialed at the breast during the study. Other groups are planning to explore normal swallowing in healthy breastfeeding infants with FEES (Mills, 2015).

Feeding Assessment

Feeding assessment is a complex process that involves observation of oral structure and oral motor functioning, as well as observation of the global body condition, including muscle tone, energy level, appropriate arousal, and aerobic capacity. All body systems participate in feeding, not just the gastrointestinal and renal systems, whose involvement is obvious. Feeding is aerobic exercise for the human infant, so the heart, lungs, and circulatory system are vital for providing the oxygen necessary for the work of feeding. The musculoskeletal system participates both in providing stability for the infant and in performing specific movements that allow milk to be transferred from the breast to the infant's mouth and into the GI tract while excluding it from the respiratory passages. Cellular respiration (mitochondrial enzymes) provides the energy for each cell from the metabolism of blood-borne glucose, which is maintained by the liver, pancreas, and hormonal systems of the body. The nervous system must work properly to direct the activities of all the other systems.

A healthy infant, given a normal environment, can perform the necessary functions to maintain life and health, one of which is feeding. As mammals, human infants have the ability to move to, attach to, and remove milk from the mammae, or breasts. Conversely, if a newborn in a normal environment cannot breastfeed, the index of suspicion is increased that all is not well. Healthy infants indicate hunger by feeding behaviors, which include lip smacking, tongue movements, hands to mouth, squirming, scanning with the cheeks, and moving themselves from an adult's shoulder down to the breast (or from the mother's belly up to the breast using the stepping reflex).

These behaviors were once seen as hunger cues, but now it is understood that they are functional behaviors that are part of the competent infant's feeding sequence. When mothers are educated to work with these normal behaviors, attachment to the breast becomes far easier.

This section will provide a framework for evaluating the infant's feeding behaviors at the breast. The purpose is to provide the reader with a system for evaluating the dynamics of feeding and swallowing from a breastfeeding perspective so an intervention plan can be developed.

Most infants seen by lactation consultants have minimal or mild disorders. These may be transient problems, such as incoordination of suck–swallow–breathe due to inexperience or poor feeding secondary to labor medications, or they may be persistent, such as the abnormal tongue movements from a tight lingual frenulum. These infants may have difficulty transferring milk at the breast but may be able to functionally bottle feed, offering false reassurance. Abnormal tongue movements may persist without intervention. In contrast, infants with moderate to severe problems are likely to have difficulty with both breastfeeding and bottle feeding and are more easily identified. Tracheomalacia or laryngomalacia (see Chapter 8) may first become apparent as feeding volumes increase over the first few days of life. Lactation consultants (LCs) may therefore be the first to identify the short sucking bursts and stressed respiration typical of a respiratory anomaly. It is important for all members of the healthcare team to work together in the baby's best interest. Breastfeeding is usually an achievable goal, given practice, milk expression to support milk production, and supplementation in a manner supportive of normal feeding skills.

Breastfeeding promotes normal physiological development and optimal growth and function of the orofacial structures. Each step in normal development depends on the step before, and though a child may be able to function using compensatory strategies, these compensations do not promote optimal development. Therefore, early intervention may avoid the need for more extensive therapy later.

Ideally, a *feeding team* addresses significant feeding and/or swallowing issues. A feeding team is a group of specialists who work together to develop an individualized feeding program for an infant or child. A pediatrician or neonatologist may serve as the medical coordinator. A speech–language pathologist, occupational therapist, nurse, and dietitian are included in the basic team. Other team members may include a social worker, psychologist, physical therapist, gastroenterologist, neurologist, otolaryngologist, pulmonologist, allergist, endocrinologist, and dentist. Team members evaluate the infant's skills from their professional perspective and report the results to the team. For example, the otolaryngologist may assess the integrity of the infant's oral, pharyngeal, and laryngeal structures through endoscopy and report to the team any abnormalities in anatomy and physiology along with suggestions for treatment. The feeding team devises a plan of action that will address the infant's needs (Arvedson & Brodsky, 2002; Arvedson & Lefton-Greif, 1998). In order to participate as a feeding team member, the LC should have an understanding of normal feeding, techniques for assessing problems, and interventions for facilitating development of feeding skills.

Factors Affecting Feeding

Gestational Age

In order to assess an infant's feeding behavior, the clinician should have an understanding of how the infant develops and what to expect in terms of reflexive oral behaviors, state, endurance, and coordination of sucking, swallowing, and respiration. The younger the gestational age of the infant, the more his or her feeding skills are likely to be disrupted by lower aerobic capacity, lower muscle tone, lower energy, and decreased neurological maturity.

Pre-existing Medical Diagnoses

Information about medical conditions that affect feeding competence will shed light on the infant's capabilities, challenges, and behaviors. It is useful to keep diagnoses in mind but also important to approach the infant as an individual with his or her own set of feeding skills. It is helpful to know if and how a medical condition typically affects feeding and swallowing, while realizing that there is always a continuum of effects and the individual may be mildly, moderately, or severely affected in each area.

Screening Tools Versus Assessment Tools

A *screening tool* identifies individuals at risk for feeding and swallowing problems by a rapid observation of signs and symptoms. An *assessment tool* provides more in-depth information as to the nature of the problem so that a plan of corrective or facilitative action can be taken (Logemann, 1998).

Current breastfeeding assessments are technically screening tools that have been devised primarily to identify which breastfeeding behaviors are present in the mother and infant and if the potential for breastfeeding to occur is present. These are predominantly observational scales in which the LC or nurse indicates the presence or absence of behaviors associated with breastfeeding. These screening tools have primarily been designed for use in the early postpartum period and may be viewed as a signal that breastfeeding is not getting off to a good start. Dyads identified as at-risk can then be referred for further assessment and intervention to protect the mother's milk production in the sensitive calibration phase and ensure the infant's nutrition.

Examples of breastfeeding screening tools that can be used with term infants are as follows:

- Infant Breastfeeding Assessment Tool
- Latch Assessment Documentation Tool
- Via Christi Breastfeeding Assessment Tool
- Mother–Baby Assessment Tool

The Preterm Infant Breastfeeding Behavior Scale (Nyqvist, Rubertsson, Ewald, & Sjöden, 1996) is an observational tool for use with preterm infants to identify pre-breastfeeding and early breastfeeding behaviors. For a complete, in-depth description of these and other breastfeeding scales, consult Walker (2006).

Other Oral-Motor Assessment Tools

Speech pathologists and occupational therapists have used observational feeding tools to assess infants' bottle-feeding behaviors in the preterm and term population. The Neonatal Oral-Motor Assessment Scale (NOMAS) was developed to assess bottle feeding, though the author states that it can be used with breastfeeding infants as well (Palmer, 2006). The NOMAS is used to rate tongue and jaw movements during both nonnutritive and nutritive sucking. Infants with problems are diagnosed with disorganized sucking if they have deficiencies of rate and rhythm, or they are diagnosed with dysfunctional sucking if they display abnormal tongue or jaw movements that interrupt the feeding (Palmer, 1998). Disorganized sucking is reflective of difficulty with suck–swallow–breathe coordination, and is common in infants who have been ventilator dependent. Dysfunctional sucking identified on the NOMAS was not predictive of later neurodevelopment in a prospective study (Zarem et al., 2013).

Another observational tool, the Early Feeding Skills (EFS) Assessment (Thoyre, Shaker, & Pridham, 2005), is a cue-based approach to feeding assessment and intervention in preterm hospitalized infants. The EFS is a checklist for determining infant readiness and tolerance for feeding based on an infant's physiologic, motor, and state regulation; oral-motor abilities; and coordination of suck–swallow–breathe.

Facilitation Versus Compensation

Techniques for assisting with feeding issues fall under two categories:

- *Facilitative strategies:* Techniques that encourage normal development
- *Compensatory strategies:* Techniques that allow for more optimal feeding but do not change the underlying problem

Examples of facilitative strategies used with breastfeeding babies include the following (adapted from treatment strategies in Hall [2001]):

- Skin-to-skin contact with the mother to increase arousal and interest in the breast
- Regulation of suck–swallow–breathe bursts (also called external pacing) with clinician-imposed pauses prior to coughing, drooling, or color changes in the infant, either by removing the infant from the breast or by pressing on the breast to block some ducts to reduce milk flow
- Oral stimulation to increase feeding readiness

Examples of compensatory strategies used with breastfeeding infants include the following:

- Approaching the infant when he or she is alert and ready to breastfeed
- Maintaining a quiet environment conducive to attending to feeding
- Attempting alternative positioning to compensate for infant or maternal anatomical variations
- Cuddling and flexing the infant when stress cues are exhibited
- Using a nipple shield when the infant has difficulty grasping the breast due to tongue-tie
- Using a nipple shield when the infant is preterm and cannot maintain attachment
- Providing cheek support when the infant has low tone, carefully observing for the ability to handle flow rate
- Providing jaw support for wide jaw excursions to prevent loss of attachment

These strategies are just a few examples of ways to improve feeding skills. The determination of what strategies are appropriate for an individual infant can be made when a complete assessment is carried out.

Clinical Breastfeeding Assessment

An in-depth breastfeeding assessment will give the clinician more specific information about the infant's feeding ability at the breast. A detailed assessment facilitates the formulation of a care plan for alleviating the problem. According to Arvedson and Lefton-Greif (1998), there are two basic questions asked during a feeding and swallowing evaluation: What is the cause of the problem? and How can it be fixed? This approach can also be adapted to the clinical breastfeeding assessment.

The steps of a clinical breastfeeding assessment are as follows:

1. Determine whether the breastfeeding problem is the result of
   a. basic positioning or attachment issues.
   b. an underlying anatomical problem in the infant (or a problematic interaction with the mother's anatomy).
   c. an underlying neurological problem in the infant.

2. Analyze the steps needed to alleviate the problem:
   a. Correct basic attachment, positioning, and management.
   b. Identify and implement compensatory techniques for anatomical problems and/or refer to another professional for further evaluation and treatment (e.g., frenotomy).
   c. Identify and implement facilitative techniques to improve neurological development and/or refer to another professional with specific expertise in this area.
3. Collaborate with the parents on an individualized plan for them to follow at home to meet their breastfeeding goals with both short-term and long-term objectives.
4. Provide education, anticipatory guidance, demonstration, and return demonstration of the techniques to be followed.
5. Arrange for follow-up.

Morris and Klein stated, "Assessment and treatment are sides of the same coin. Each assessment contains treatment probes to discover the most effective approaches to remediating the difficulties that have brought the child and family for the evaluation" (2000, p. 174). This perspective can also apply to the clinical breastfeeding evaluation, where compensatory and facilitative techniques can be incorporated by the clinician. Both compensatory and facilitative techniques should be practiced during the assessment to determine their effectiveness in enhancing feeding skills. If successful, they can be incorporated into the feeding plan.

The clinical assessment consists of several areas of evaluation. Some clinicians carry out all of the following areas, whereas some focus only on specific areas:

- Oral sensorimotor observation of the infant and digital suck examination
- Breast examination of the mother
- Breastfeeding assessment of the infant and mother, including assessment of milk transfer
- Assessment of feeding using compensatory techniques, facilitative techniques, and alternate feeding devices (when appropriate)
- Milk expression (when appropriate)

Global Observations of the Infant

As part of the initial portion of the assessment, it is useful to globally observe the following characteristics related to the infant's neurological and physiological functioning:

- Tone
- Grading of movement
- Symmetry
- State and level of arousal or alertness
- Respiratory pattern
- Color

This information will be used as a baseline for comparison when the infant is engaged in feeding. A global assessment is useful because it can yield information that will contribute to the clinician's understanding of what may be happening during a feeding. The following information provides some guidelines.

Tone

An infant with low muscle tone may let the extremities hang, recruit accessory muscles to help maintain stability, or use fixing to help compensate (see Chapter 11). There may be hypotonia in the facial area, where the infant appears expressionless. At the breast, the hypotonic infant may lose suction and spill milk from the mouth. A hypertonic infant may exhibit arching when put to the breast and have a retracting jaw when sucking. Hypertonic infants may seem stiff and may have difficulty opening the mouth wide (gaping) and initiating sucking bursts. These effects and compensations are usually easily visible, as are excessive excursions (downward movements) of the mandible that cause the lip seal to be disrupted. See **Figures 1-5 through 1-7** for examples of infants with hypotonia and normal muscle tone. Infants may increase their tone in response to stress. The facial expression (wide or narrowed eyes, furrowed forehead) will usually help differentiate a stressed infant from a hypertonic one.

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Figure 1-5 Infant with benign neonatal hypotonia. Note that the mouth hangs open and arms fall to the side of the body.

Grading of Movement

Infant grading (smoothness) of motion generally depends on stability. Neurologist Amiel-Tison noted that social interaction and head and neck support improved fine motor control

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Figure 1-6 Infant with normal muscle tone. Note the crisp creases from normal contraction of the muscles of facial expression.

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Figure 1-7 Infant with hypotonia due to Down syndrome. Note the expressionless look due to low tone of facial muscles.

in neonates (Gosselin, 2005). When prone on the semi-reclined mother's trunk or abdomen, infants are capable of remarkably accurate movement (Colson et al., 2008). A head lift cannot generally be maintained more than a second or two, but that is long enough for the baby to bob his or her way to the breast. The quality of grading will also be apparent in the jaw movement. The movements should be smooth and equal, in midline, with a slight pause or bounce or accentuation of the downward jaw excursion as the baby maintains negative pressure in the mouth and draws milk from the breast.

Symmetry

Symmetry across the midline is an indication of equal nerve and muscle activity on each side of the body. Nerve palsies, birth injuries, and adverse effects of restricted in utero positioning, such as torticollis, may all cause asymmetry and feeding difficulties (**Figures 1-8 and 1-9**).

State and Level of Arousal (Alertness)

Infants who are transferring milk are usually alert, with open eyes and an intent facial expression. As the feeding progresses and the baby becomes sated, the fingers generally relax and open, the eyes close, and the muscle tone softens. Infants who are hyper-aroused may cry or be unable to inhibit rooting and move on to the next step of attachment. Most LCs have seen infants who shake their heads furiously, trying to identify the nipple when it is already in the mouth. Sliding the baby's body toward the mother's contralateral breast and bringing the lower lip and tongue closer to the areolar margin (and farther from the nipple) will often allow the tongue to contact the breast and the baby to attach. Using gravity (with a semi-reclined maternal position) so the infant's chin digs into the breast may achieve the same goal. Infants

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Figure 1-8 Facial and neck asymmetry from torticollis.

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Figure 1-9 Normal symmetry.

Table 1-3 Respiratory Pattern

Resting Respiratory Rates for Infants	Breaths per Minute
Term infant	30–40
Preterm infant	40–60 (reflects cardiorespiratory immaturity)
Ill infant	60–80

Reproduced from Hough, 1991, as cited in Arvedson, J. C., & Lefton-Greif, M. A. (1998). *Pediatric videofluoroscopic swallow studies: A professional manual with caregiver guidelines*. San Antonio, TX: Therapy Skill Builders (Harcourt).

who are under-aroused may fall asleep before attaching. Infants who find feeding threatening or stressful will show motoric, behavioral, and autonomic signs, including color changes, increased respiratory rate, tone changes, yawning, tuning out, and crying (see Chapter 10).

Respiratory Pattern

An infant's respiratory rate (RR) must be slow enough to coordinate with sucking and swallowing (**Table 1-3**). Though most infants are not able to feed with an RR over 80, if the infant is willing to breastfeed, he or she is probably capable of doing so. It is normal for RR to increase during respiratory pauses in feeding, but it should stabilize again before the infant begins another sucking burst. Respiratory effort should remain normal through the feeding; overuse of chest or throat muscles during breathing indicate excessive work of respiration. Short sucking bursts with long respiratory pauses may indicate cardiorespiratory immaturity or instability.

Color

Changes in skin color can reflect reduced oxygenation due to cardiorespiratory problems or autonomic instability secondary to stress. These are most apparent around the mouth, eyes, and nipples, and in the hands and feet. Mottling usually reflects a chilled infant. Pallor, duskiness, and cyanosis (blueness) are signs of reduced tissue oxygenation. Flushed and ruddy colorations are usually a sign of autonomic instability. A gray infant may have a cardiac problem, particularly if the infant is perspiring. (See **Plates 1 and 3** for photos of cyanosis.)

Neurological Screen of the Infant

Probing the infant's reflexes reveals valuable information about the infant's neurological status. Table 1-1 summarizes the information necessary to assess the cranial nerves and reflexes the infant uses in feeding (adaptive reflexes) and airway protection (protective reflexes). An alert infant who does not exhibit adaptive behaviors may have a neurological deficit.

Oral Assessment of the Infant

A visual examination of the infant's oral structures will provide useful information regarding the structures at rest and in isolated movements. The clinician may also want to do a digital examination of the infant sucking nonnutritively to assess the tongue's range of motion and strength, as well as the integrity of the central pattern generator for sucking. Sucking behavior is better assessed when fluid (a few drops of expressed milk from a dropper or syringe) is used during a digital suck exam. This allows evaluation of sequential tongue movements, adaptability to different flow conditions, and coordination of sucking, swallowing, and breathing. It is normal for infants to modulate sucking pressure in response to milk flow. During nonnutritive sucking, the hungry neurotypical infant keeps increasing the sucking pressure in an attempt to get milk and will decrease sucking pressure when milk is delivered.

Offering a finger across the baby's lips for them to grasp rather than inserting the finger into the mouth shows respect for the infant's personhood, assesses the gape and oral grasp responses, and prepares him or her to suck. When the infant opens the mouth, allow the gloved finger to touch the tip of the tongue and observe whether the infant draws the finger in or not. If the tongue retracts, note this and try to stimulate the front of the lower gum to see if the infant will extend the tongue. When the infant draws the finger in, note how well the tongue grooves around the finger and the strength of the tongue movements. When the fingertip is near the junction of the hard and soft palate, the infant will generally begin to suck. Note how well the infant maintains contact with your finger during the suck. After assessing the nonnutritive suck, give some drops of expressed milk and note any changes in the sucking pattern. The infant should be able to keep the anterior tongue grooved around your finger while the jaw drops slightly and the posterior tongue drops from front to back to create negative pressure. The sucking should be deep, drawing, and rhythmic. If the anterior tongue loses contact with the finger, the infant may lose the latch; if the tongue retracts, allowing the tooth-bearing surface of the lower gum ridge to contact the finger, the infant will bite or chew. Note any sliding of the tongue. If this occurs on the finger, it will likely be worse on the breast because the mouth is more open while breastfeeding than finger sucking, providing more challenge to tongue mobility. A forceful posterior tongue elevation or high vacuums are other compensations that can be identified on a digital suck exam.

Neurologically impaired infants may lack sequential graded tongue movements; the tongue may move up and down in the mouth in an uncoordinated manner. Infants who are unable to groove the anterior tongue will hold the breast with a flat anterior tongue pushed up to the palate, which requires more muscular effort and pressure to maintain a stable mouthful.

Tongue

A well-coordinated tongue that has full range of motion is of great importance in feeding and the oral stage of swallowing. Note the tongue's appearance, any anatomical variations, and symmetry or asymmetry of movements. The clinician can observe tongue movements while interacting with the infant or elicit them with a gloved finger. The following movements can be observed or elicited, and any inabilities or limited abilities to perform the movements can be recorded along with possible causes:

- Ability to protrude or extend tongue (during quiet alert state interactions or when the lower gum ridge is stimulated with the clinician's fingertip (**Figure 1-10**)
- Ability to lateralize tongue (when the outer gum ridge is stroked from the center to the side by the clinician's digit (**Figure 1-11**) equally to both sides

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Figure 1-10 (Above) Normal tongue extension.

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Figure 1-11 (Top right) Normal lateralization.

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Figure 1-12 (Right) Normal elevation.

- Ability to elevate tongue (observe for elevation of the tongue tip to the palate if the infant cries or attempt to stimulate this action by touching the upper gum ridge with a gloved finger (**Figure 1-12**)

Anatomical Variations of the Tongue. The relative tongue length may impact feeding skills. A short tongue may restrict the ability to attach to the breast, and a long tongue may be held on the palate and may not develop normal coordination. A submucosal frenulum may retract the tongue and make it appear short (see Chapter 9), but a truly short tongue will have normal mobility.

Asymmetry of the tongue can be structural or can result from an underlying neurological problem, in which case the tongue deviates to the stronger side (**Figure 1-13**). A flat tongue may indicate low tone or a severe tongue-tie (**Figure 1-14**). Infants with decreased muscle tone, an excessively large tongue, or a small mandible may also protrude their tongue at rest. Preterm infants may adopt an open-mouth posture with the tongue protruded in an effort to open the airway when there are respiratory issues. Tongue tip elevation in a preterm infant indicates stressed respiratory status and unreadiness to feed. (See **Plate 7** for a photo of an infant

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Figure 1-13 Asymmetrical tongue movement due to tongue-tie.

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Figure 1-14 Flat tongue due to both tongue-tie and hypotonia.

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Figure 1-15 Tongue retraction and posterior elevation (humping) due to tongue-tie.

fixing the tongue to the palate.) Changing the infant's position to reduce respiratory stress (particularly placing the baby skin to skin with the mother) may improve feeding readiness.

An infant with posterior tongue elevation (humping) at rest will block the oral cavity and make attachment difficult (**Figure 1-15**). A tongue with a thick, bunched configuration that distributes its muscle mass posteriorly when retracting may be restricted by a tight lingual frenulum.

Tongue retraction also prevents the tongue from grasping the breast and is a common cause of latch failure. It is often postulated that infants who have had unpleasant oral experiences will use the tongue to block access to the mouth. Although this is not proven, infants are sentient beings and deserve to be treated with respect.

Range of motion is perhaps the most important factor in an infant's ability to breastfeed with tongue-tie. A thin, elastic frenulum will generally impact tongue movement less than a thick, fibrous one will. Elasticity of the floor of the mouth may partially compensate for a restrictive lingual frenulum. If the floor of the mouth is tight and the frenulum is short and inelastic, the infant is at risk for very poor tongue function. The extent of the lingual frenulum along the underside of the tongue is another important determinant of function, with a longer

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Figure 1-16 Bunched tongue due to tongue-tie. Note how the entire length of the tongue is pulled down in midline by the frenulum.

attachment generally restricting tongue elevation and extension more than a shorter one of equal thickness and elasticity.

A severely restrictive lingual frenulum will usually keep the tongue behind the gum line, especially as the mouth opens. The tongue will appear flat or bunched into an unusual configuration (**Figure 1-16**). Touching the future tooth-bearing surface of the exposed lower gum ridge triggers reflexive biting, which is normally inhibited by the presence of the tongue tip.

The combination of inability to elevate the tongue to grasp the breast and the triggering of the normal phasic bite reflex causes these infants to chew at the breast.

Fasciculations or Tremors of the Tongue and/or Mandible. Neurologically immature or impaired infants can exhibit tremors during activity or at rest due to insufficient muscle activation by the brain (see Chapter 11). Muscle fasciculations can also occur due to fatigue in tongue-tied infants who recruit accessory muscles and use less ergonomic compensatory sucking strategies. These are a reliable sign that the infant is working too hard to feed. Oral anatomy and oral motor function should be thoroughly assessed when tremors occur, and growth should be followed closely.

Lips

Lips are gently applied to the breast with the lower lip flanged completely outward and the upper lip neutral to lightly flanged. A very tight superior labial frenulum can produce sucking blisters on the mucosal surface of the upper lip (**Figure 1-17**) and may make it more difficult to maintain latch. Infants with restrictive tongue attachments may use sweeping motions of the upper lip during sucking, causing a large sucking blister on the vermillion of the upper lip. Observe the lips and note any anatomical variations. Make note of any asymmetry, which is often due to nerve damage and muscle weakness that causes the lip to deviate (pull) toward the stronger side. Increased or decreased tone can occur with neurological deficits.

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Figure 1-17 Tight labial frenulum. Note the large blister on the center of the upper lip.

A deep indentation of the upper lip vermillion (gull wing sign), especially when paired with a paranasal bulge, can indicate the presence of an occult submucosal cleft (Stal, 1998)

(**Figure 1-18**). A cleft of the lip may or may not influence the infant's ability to breastfeed, depending on the existence of a concomitant submucous cleft of the palate and how well the mother's breast tissue fills the defect.

Nose

The nose should be symmetrical, and the infant should be able to breathe at rest without flaring the nares (nostrils). Flared nares (**Figure 1-19**) indicate increased effort of breathing. Note any congestion, discharge, sounds of effortful nasal respiration, or the presence of nasal regurgitation (**Figure 1-20**), which can indicate soft palate cleft or incomplete closure (velopharyngeal dysfunction). Nasal regurgitation can sometimes be as subtle as white, milky nasal mucous.

Cheeks

Full-term infants have fat pads within the buccal muscles that give their cheeks a full, rounded appearance. The purpose of these fat pads is to provide lateral stability during the first few months, supporting the tongue in a grooved position around the teat. Preterm infants, depending on gestational age, may not have fully developed fat pads and may suffer cheek collapse during sucking that reduces their ability to create intraoral negative pressure. Record any anatomical variations, asymmetries, or tonal differences between the cheeks.

Jaw

Tongue and jaw movements are linked and synchronized during sucking. Infants typically have a receded jaw, but one that is unusually receded can reduce the mechanical advantage of the jaw during sucking. Reduced alignment of the maxilla and mandible can reduce milk transfer. It is unusual for an infant to have a protruded jaw. Asymmetry of the jaw opening may

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Figure 1-18 Gull wing sign and paranasal bulge in a toddler with soft palate dysfunction.

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Figure 1-19 Flared nostrils.

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Figure 1-20 Simultaneous regurgitation from mouth and nose.

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Figure 1-21 Mandibular asymmetry due to congenital muscular torticollis.

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Figure 1-22 Subtle asymmetry in an infant with feeding difficulties.

indicate congenital torticollis (Wall & Glass, 2006) (**Figure 1-21**). Other signs of torticollis include the infant's head turning to one side with a flattened occiput on that side (plagiocephaly) and the head tilting toward the opposite side with neck shortening and limited range of movement. The skin creases at the base of the neck on the infant's back will be asymmetrical. Additional signs include asymmetrical placement of the eyes and ears, with one eye appearing larger than the other (**Figure 1-22**). The ear on the compressed side is usually cupped outward, and the contralateral ear is flattened to the skull. The unilateral upward tilt of the lower jaw and alveolar ridge in infants with torticollis contributes to feeding difficulty. Severe torticollis may result in increased tone and rotation of the body all the way down the affected side. Infants with torticollis require immediate referral for occupational or physical therapy or other effective bodywork. See Chapter 8 for more on congenital torticollis.

Wide jaw excursions that disrupt the attachment or clenching where the jaw moves minimally are problematic. The disorganized infant with immature sucking abilities may have inconsistent jaw movements, arrhythmic movements, or difficulty initiating movements (**Figure 1-23**).

Hard and Soft Palates

The hard palate is continuous with the alveolar (gum) ridge in the front and the soft palate (the movable portion) positioned posteriorly. The movement of the soft palate may be noted if a gag reflex is elicited or when the infant cries. Clefts are the most obvious deviation affecting the palates (**Figure 1-24**). Even a submucosal cleft may affect the infant's ability to produce suction and effectively breastfeed (see Chapter 8). It is difficult to see the soft palate in a young infant, because the tongue fills the mouth. Strategies for better visualizing the posterior palate include digital photography, using a tongue depressor, and stimulation of the gag reflex at the soft palate with a cotton swab. Asymmetries in soft palate movements (just as in the tongue) can indicate a neurological deficit.

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Figure 1-23 (Above) Excessive jaw excursion causes the infant to lose contact with the breast with his tongue and upper lip.

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Figure 1-24 (Top right) Cleft of the soft palate.

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Figure 1-25 (Middle right) High-arched, narrow palate due to tongue-tie.

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Figure 1-26 (Bottom right) High-arched, unusually shaped palate caused by a genetic deletion syndrome (Phelan-McDermid syndrome).

A highly arched or narrow hard palate is an indication of abnormal or restricted tongue movement (**Figures 1-25 and 1-26**). The tongue normally shapes the palate, widening it into a broad U-shape. It is unclear if there is any contribution of a high palate to breastfeeding difficulty in and of itself, and in our research, narrow infant palates due to tongue-tie have spontaneously broadened in the weeks after frenotomy. A high, narrow palate may be hypersensitive to stimulation due to lack of tongue contact in utero. The resultant hyperactive gag reflex may make the infant reluctant to accept the breast deeply into the mouth and may interfere even more with the acceptance of firmer objects.

A preterm or ill infant whose history includes intubation or orogastric tube feedings may have a channel palate from the pressure of the narrow tube. Infants who have experienced repeated invasive oral procedures may develop hypersensitivity and aversion that may influence their willingness to accept anything into their mouth. Infants who have required intensive care may also be fearful of being held. They may need gentle desensitization, starting with holding in a way that they can accept (perhaps with their back toward the mother) and moving gradually toward a breastfeeding position.

Breast Assessment of the Mother

The focus of this text is the infant; however, breastfeeding requires a dyad. Anatomical mismatches between the mother and the infant influence the infant's feeding abilities. Look at the mother's breasts to see how well the infant's limitations may be accommodated.

Breast Characteristics

Mild breast hypoplasia may be less problematic with a vigorous infant than a challenged one. Increased intermammary spacing (more than 1.5 inches) increases the index of suspicion for decreased glandular development in the breasts, as does breast asymmetry (**Figures 1-27 through 1-29**). Persistent maternal Tanner stage-4 breasts (bulbous areolas) may improve feeding ability for some infants and be disadvantageous for others. Flat or inverted nipples (**Figures 1-30 and 1-31**) will be more challenging for a tongue-tied or hypotonic infant to grasp, whereas long nipples may be difficult for a child with a hyperactive gag. Wide, inelastic nipple tissue may make feeding ineffective for infants with small mouths until they grow into them. The placement of the nipple on the breast will determine what positions will be most effective for the individual dyad. Maternal motor skills and previous breastfeeding exposure and experience all contribute to the support the mother can offer her infant.

Breastfeeding Assessment

Tools

When sucking problems exist, pre- and postfeeding weights need to be measured in the same clothing on a sensitive digital scale designed for test weighing. A penlight or otoscope is helpful in visualizing oral structures. A neonatal stethoscope is helpful for cervical auscultation (listening at the neck or underside of the chin) to assess swallowing sounds and coordination of swallowing and breathing (Box 1-6). A digital camera or camcorder helps to preserve information for future re-evaluation, and photos or videos may be provided to the mother as teaching tools or to the infant's physician as documentation. Even experienced clinicians may notice important details that were initially missed when reviewing such documentation.

Compensatory Strategies

Based on the assessments, the following techniques could be employed to enhance breastfeeding given the anatomical limitations of the mother and/or baby:

- Positioning to enhance support and maximize attachment
- Nipple shield to make nipple or areola more graspable

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Figure 1-27 (Top left) Mild hypoplasia with wide intramammary space and high inframammary fold.

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Figure 1-28 (Top right) Breast asymmetry, with use of a Lact-Aid nursing trainer due to lower milk production in the smaller breast.

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Figure 1-29 (Middle right) Severe breast hypoplasia.

Figure 1-30 (Bottom left) Inverted nipple.

Figure 1-31 (Bottom right) Breast engorgement flattens the nipple and makes attachment difficult.

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- Reverse pressure softening (RPS) (Cotterman, 2004), therapeutic breast massage (Bolman, Saju, Oganesyan, Kondrashova, & Witt, 2013) or brief pre-pumping to soften the nipple and areola area to make it more elastic
- Using a nipple everter device, such as a Supple Cup (www.supplecups.com), before feeding to make the nipple more prominent and graspable (Bouchet-Horwitz, 2011)
- Breast compression or massage to increase milk flow
- Filling tip of nipple shield with syringe or tubing attached to syringe to stimulate sucking
- At-breast supplementation to improve milk transfer

Observation

Attachment and positioning are essential to infant performance at the breast. Look at infant support and alignment; complete contact between mother's body and infant's chin, chest, trunk, and abdomen; hip flexion around the mother's side; and maternal ergonomics and comfort (**Figures 1-32 and 1-33**). Note how much assistance the mother requires to provide optimal support for her infant. Biological nurturing (laid-back or semi-reclined) maternal positions improve ergonomics, gravitational support, and reflex behaviors in both partners (Colson, 2007a; Colson, 2007b).

Stimuli that best trigger the inborn neurobehavioral feeding program in human infants include skin-to-skin contact with the mother, chin contact with the breast, and nipple contact with the philtrum (ridge between upper lip and nose). When given these cues, a hungry infant will gape widely, extend and depress the tongue, grasp the breast and seal to it with the tongue and lips, and begin sucking.

Tongue

The infant's tongue position during approach to the breast is one of the most important factors in successful attachment. The tongue is down in the mouth over the lower gum or lip. At the point of latch, the anterior portion of the tongue lifts upward to contact the breast as the tissue is drawn into the mouth. Optimal attachment is vital to filling the mouth and stabilizing the tongue so it can function as well as possible.

Ankyloglossia (tongue-tie) often has a negative effect on feeding and requires frenotomy in half of affected infants (Todd & Hogan, 2015). Although some tongue-tied infants are able to latch and transfer milk (Geddes, Kent et al., 2010), most are less efficient than their peers with unrestricted tongue motion (Geddes, Langton et al., 2008; Ramsay, Langton, Jacobs, Gollow, & Simmer, 2004). Others are unable to attach to the breast at all (**Figure 1-34**). Some infants attach but fail to transfer enough milk to sustain growth and

If the Infant Initiates Sucking Before Attaching and Is Unable to Latch

Facilitative strategy: Ask the mother to take the infant away from the breast, wait until the infant stops sucking, and then begin again. Because sucking is reflexive in the first few months, the infant may persist in the pattern without assistance from the mother.

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Figure 1-32 Good alignment allows the infant to self-attach to the breast.

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Figure 1-33 Placement of the infant where the breast naturally falls, and supporting him against the mother's body, is usually more ergonomic for the mother and gives the infant optimal stability.

stimulate maternal supply, or they may cause maternal nipple or breast damage due to repetitive stress from abnormal movements of the tongue. Ask the mother about her sensations during feeding. Pinching or biting sensations may be due to excessive positive pressure from the tongue or jaws; friction (often described as feeling like sandpaper or a cat's tongue on the nipple)

If Tongue Tip Elevation Obstructs Attachment

When the infant is not lowering the tongue tip, try the following strategies to encourage the infant to lower it.

Facilitative strategies:

- Allow the infant more time to organize oral movements and drop the tongue to begin nuzzling and licking the breast.
- Tickle down the tongue tip with an adult finger immediately before attachment, which might help if the infant does not spontaneously drop the tongue.
- Briefly fingerfeed some expressed milk. Fingerfeeding can be useful for habitual tongue-tip elevation by teaching the infant that food belongs on top of the tongue.
- Watch for rapid respirations to determine if the infant is able to feed. The infant needs to be able to spare time in the respiratory cycle to close the airway for a safe swallow. Rapid respiration implies difficulty meeting oxygen needs at rest; oxygen needs are greater during feeding. Helping the infant organize may reduce their respiratory rate (rocking, cuddling, reducing environmental noise and light). Positioning changes (prone with head extension) during feeding can open the airway and ease breathing.

Compensatory strategies:

- A silicone nipple shield may provide stronger tactile input and allow the infant to slide the tongue under the teat during the learning period.
- Supplementary oxygen (provided by nasal cannula or "blow by") during feeding for infants with tongue-tip elevation secondary to rapid respiration.

Figure 1-34 This infant with tongue-tie cries in frustration from the absence of his expected cue (tongue tip on breast), which causes his tongue to elevate and block the mouth.

may be due to compensatory in–out (sliding) movements of the tongue; and feeling percussive movement against the nipple may be due to excessive posterior tongue elevation (humping; see Chapter 8). Pain without evidence of damage may be from nipple base compression (Geddes, Langton et al., 2008) or from excessive negative (suction) pressures during sucking (McClellan et al., 2008). Excessive pressures during sucking can be ameliorated with the use of a nipple shield (D. T. Geddes, personal communication, May 2007) or the use of a piece of thin supplementer tubing to vent the mouth (R. Noble, personal communication, May 2013).

Lips

Hoover (1996) found that breastfeeding was pain-free if the infant's lip angle was 130 to 160 degrees. In young infants, the angle of the lips will often be hidden by the cheeks, which contact the breast and remain rounded. The nasolabial crease should remain soft, and the upper lip should be neutral to slightly everted on the breast and should be relatively immobile during sucking. Older infants and toddlers generally do not touch the breast with their cheeks during breastfeeding. Their lip angle should be at least 130 degrees to ensure maternal comfort. See **Figure 1-35** for an example of ineffective latch and **Figure 1-36** for an example of optimal latch.

Overuse of the upper lip is associated with large sucking blisters and is easily visible as a sweeping motion of the lip during feeding. It may be associated with in-and-out movement of the breast.

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Figure 1-35 An overly flanged upper lip is a sign of shallow attachment or overuse of the lip to compensate for tongue immobility. This infant's head is flexed, bringing his nose into the breast and the chin away, reducing mechanical advantage.

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Figure 1-36 Optimal latch for a young infant. The upper lip is neutral, cheeks are rounded, head is slightly extended, chin is on the breast, and nose is free.

If the Tongue Is Retracted or Unable to Grasp the Breast

Facilitative strategy: Massage the tongue with a fingertip until it extends over the lower gum. Fingerfeed for one or more feedings.

If the Tongue Tip Is Humped or Blocking the Infant's Oral Cavity

Facilitative strategy: Massage the posterior tongue, drawing gently forward in the baby's mouth. Fingerfeed with gentle counterpressure to the humped area of the tongue.

Facilitative strategy: Increase the depth of attachment, try slightly increasing head extension, check for tongue-tie, and work on strengthening the tongue movements.

Jaw

Latching infants need to open their mouth widely to grasp enough breast tissue to efficiently transfer milk. The jaw movements should be smooth, with a slight pulse on the downward component and a slight pause with the jaw open as the mouth fills with milk. Grading of jaw opening and closing should be smooth. Infants displaying jerky movements, snapping at the temporomandibular joint, or sideways or circular jaw movements should be referred for speech therapy. Depending on the etiology, bodywork might help.

Facilitative strategy: Counterpressure in front of the ear can smooth jaw movement and increase the efficiency of sucking in infants with articular disc dislocation (popping jaw) (**Figure 1-37**).

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Figure 1-37 Counterpressure alongside the tragus (ear flap) helps the temporomandibular joint glide properly in infants with articular disc dislocation and a popping jaw.

Cheeks

In newborns, the cheeks should press against the breast, hiding the lower lip, which is completely everted. The cheeks should remain smooth during sucking. Shallow attachment will cause a tight everted upper lip, excessive movement of the upper lip, tight nasolabial creases, and dimpling of the cheek during sucking (**Figures 1-38 and 1-39**). Dimpling of the cheek could also indicate buccinator weakness and instability or failure of the anterior tongue to elevate and groove to hold the breast in the mouth.

Facilitative strategy: For preterm or low-tone infants with poor cheek tone or inadequate sucking pads, provide cheek support (press into the cheeks with thumb and fingertip and draw toward the breast, maintaining gentle traction).

Feeding at the Breast

Sucking speed is inversely proportional to milk flow. Before the milk ejection reflex (MER), the infant may suck rapidly, with two sucks per second

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Figure 1-38 Dimpled cheek from shallow attachment. Note that the shoulders are rotated away from the mother.

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Figure 1-39 Same infant, better alignment and attachment.

and infrequent swallows. The sucks are shallower, with less jaw excursion than sucking after the MER. During rapid milk flow, the infant generally sucks about once per second, with a 1:1:1 suck–swallow–breathe ratio. During slower but still significant milk flow, the ratio can be 2:1:1. A ratio of 3:1:1 is considered the break-even point, whereby energy expended in feeding equals calories taken in. Larger numbers of sucks between swallows generally indicate little milk transfer. However, at the end of a normal feeding, the infant may "linger over dessert," ingesting very high-fat milk, and ideally should *not* be taken off the breast. A sated infant will release the breast voluntarily and rest on the mother's body. An infant who comes off the breast and is squirming around generally wants to take the other breast in search of a faster milk flow.

If the Tongue Tip Is Elevated or Blocking the Infant's Oral Cavity

Facilitative strategy: Tickle the tongue tip down, and calm the infant.

Normal sucking bursts consist of 10 to 30 suck–swallow–breathe triads, followed by a 3- to 5-second respiratory pause. Breathing is initially rapid during the respiratory pause, and when it returns to baseline, the infant resumes sucking. Swallowing sounds are normally subtle, with a quiet "cuh" sound representing the soft palate closing off the nasopharynx to prevent milk from entering the nose. As the baby adjusts to a new milk ejection, swallowing may become slightly louder. Gulping sounds (hard swallows) represent stressed or difficult swallowing and are counterintuitively associated with small boluses.

Observation of the infant's burst pause pattern can reveal cardiorespiratory instability—the sucking bursts will be short, consisting of 3–5 sucks with prolonged respiratory pauses during which breathing is rapid, loud, or stressed. Immature infants may use a transitional sucking pattern consisting of 5–8 sucks and swallows with breathing mostly between sucking bursts (Palmer, 1993). Difficulty coordinating sucking, swallowing, and breathing can manifest as gulping, coughing, color changes, aerophagia (air swallowing), and short bursts of stridor (high-pitched breathing, in this case, occurring as the vocal folds snap shut to keep milk out of the airway during *laryngeal penetration* in a poorly timed swallow). The difficulty can stem from maternal hyperlactation and rapid milk flow or, more frequently, from the infant's inability to handle a normal flow. Infants with mild difficulties will usually respond to being removed from the breast briefly for a respiratory pause or feeding in a prone or side-lying position (**Figure 1-40**). Steady pressure

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Figure 1-40 Infant in prone position on semi-reclined mother. This ergonomic position improves stability and ability to handle milk flow.

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Figure 1-41 Mother presses on breast to block some ducts to slow flow. Idea from Carol Chamblin.

on the breast with the side of the mother's hand during the first and strongest milk ejection will block off the flow in the occluded ducts and slow the flow (**Figure 1-41**). The mother's hand should be placed as close to the areolar margin as possible without disrupting the infant's latch, since many of the large ducts are superficial and branch close to the nipple (D. T. Geddes, Personal communication, May 2007; Geddes, 2009). Infants with severe difficulties with flow may refuse to feed or become fussy during feeding, especially as they approach 3 months of age, when neck growth separates the epiglottis and soft palate and allows the tongue to drop in the oral cavity, reducing the anatomical protection against aspiration.

Ineffective Sucking or Low Maternal Milk Flow?

Ask the mother to express milk for a few minutes. If several ounces are obtained, the problem is likely with the infant. If several milliliters are obtained, the problem may be with the mother, or the supply may have responded to the infant's inability to drive it. A careful history will help tease out the factors that contributed to the poor feeding or low production.

A periodontal (curved-tip) syringe or syringe and feeding tube can be used diagnostically at the breast in such cases to see how the baby suckles with a better milk flow. If the baby does well with the additional flow, supplementing at the breast preserves breastfeeding while the supply is rebuilt.

If the infant is still not capable of transferring milk, the milk production will falter if expression does not occur frequently—approximately eight times per day (Hill, Aldag, & Chatterton, 2001).

Mothers with very low milk production may benefit from several days of ultra-frequent milk expression, or "powerpumping." Feeding with expressed milk and brief breastfeeding for practice may be the best use of the dyad's energy if the infant's feeding skills are particularly poor.

Respiratory Pattern

Infants take breathing breaks whenever they need to in order to maintain normal blood oxygen levels, as long as the flow of milk is under their control. It was once thought that infants could swallow and breathe simultaneously, due to the anatomical proximity of the soft palate and epiglottis. Although this arrangement does help protect them from aspiration, intricate coordination is still required between swallowing and breathing, as the paths for food and air cross in the pharyngeal region. Therefore, swallowing requires a brief interruption of breathing. Breastfed infants frequently swallow after inspiration or expiration is completed (Kelly et al., 2007; Mizuno & Ueda, 2006; Prieto et al., 1996), limiting the potential for aspiration.

Colostrum is viscous and present in relatively low volumes, probably allowing a training period for safer practice of this coordination. Weber et al. (1986) identified improvements in coordination of breathing and feeding in breastfed infants during the first 5 days of life.

Respiration during sucking pauses should be quiet, unlabored, and usually slightly more rapid than breathing during the sucking bursts. Infants with high baseline respiratory rates or increased work of breathing might not be able to afford the respiratory pauses of frequent swallowing.

These infants will generally use short sucking bursts and longer respiratory pauses to meet their conflicting needs for nutrition and oxygen, respectively. No attempts should be made to prod the infant. When the respiratory rate returns to baseline, the infant will begin to suckle again. This ability to self-regulate is one of the reasons that physiologic stability is greater during breastfeeding than during bottle feeding. Infants with reduced aerobic capacity generally need to be fed more frequently to make up for their longer pauses and reduced work capacity.

Signs of respiratory difficulties include the following:

- Rapid, panting respiration during pauses
- Unusual respiratory noises:
  - Stridor (high-pitched sounds from airflow turbulence during airway narrowing), which is apparent:
    - on inspiration if airway instability is at the level of the larynx.
    - biphasically (during both in and out breaths) if the narrowing is subglottic.
    - on expiration if the airway collapse is at the level of the trachea.
  - Stertor (snoring sounds from nasopharynx obstruction)
  - Wheezing (bronchial narrowing or inflammation, bronchiolitis)
  - Grunting (partial closure of glottis while exhaling, attempt to increase oxygenation; of concern if it continues beyond 60–120 minutes after birth) (Yost, Young, & Buchi, 2001)
- Harsh and wet respiratory sounds (may be due to nasopharyngeal back-flow, velopharygneal insufficiency, or aspiration)
- Retractions at the suprasternal notch, between the ribs (intercostal) or below the ribs (subcostal); signals use of accessory muscles, effortful breathing
- Mouth breathing (nasal blockage or deviated septum) (**Figure 1-42**)
- Short sucking bursts
- Loss of milk through the lips (spilling) or nose (nasal regurgitation or nasopharyngeal reflux)

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Figure 1-42 Infant with upper respiratory obstruction displays mouth breathing and worried facial expression.

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Figure 1-43 Infants remove themselves from the breast when satiated.

- Apnea, bradycardia, and desaturation
- Color changes
- Panting or purring (cardiac issue causing pulmonary hypertension)

If the infant does not have the aerobic capacity to breastfeed, prompt medical assessment is warranted. Evolving cardiac issues (aortic stenosis, transposition of the great vessels) become life threatening as the ductus arteriosus closes in the first days of life. Anomalous cardio-pulmonary vasculature becomes symptomatic as pulmonary vascular resistance changes over the first 6–12 weeks. (See Chapter 8.)

Indications of Satiety

In addition to pre- and postfeeding weight, observation of infant body language will provide clues that the infant has taken sufficient milk. When sated, a young infant will release the breast, rest his or her face on the mother's breast, and go to sleep (**Figure 1-43**). In addition, the hands generally relax from a fisted posture to gentle flexion of the fingers as the baby is satisfied. Older infants will let go of the breast and woo the mother into interaction. During the more distractible stages of development (4–6 months) the baby may come on and off the breast, alternating eating with engaging the mother's attention or paying attention to other interesting environmental happenings.

Infants who regularly fall asleep at the breast without removing themselves might not be getting sufficient milk, particularly if they protest or begin to suckle again when attempts are made to remove them or put them down. Breastfeeding sessions that consistently last more than 40 minutes indicate the infant is feeding ineffectively.

Developing a Feeding Plan with the Mother

Careful assessment with attention to the infant's structure and functioning, the feeding skills that are present, and those that are yet to develop provides a framework for choosing interventions. The feeding plan provides compensations and facilitations to ensure the infant's present nutrition while building future feeding skills.

Basic management issues are easily solved with maternal education and practice with improved positioning and attachment. More complex feeding problems require a multistep plan. Some possible components of the plan include the following:

- Referral to physicians if anatomical or neurological issues are suspected
- Alternative feeding methods while working toward transition to exclusive breastfeeding
- Maintaining or increasing milk production by pumping with a multi-user breast pump with a double kit at least eight times each day
- Encouraging skin-to-skin contact and comfort sucking at the breast when the infant is not hungry to maintain interest in breastfeeding
- Positioning and attachment techniques based on the results of evaluation
- Determining whether oral exercises are appropriate; specific oral exercises are selected to reduce maladaptive movements and encourage correct ones

New procedures should be demonstrated, and the parents should return the demonstration to assure that the techniques are understood. Written instructions should be provided. Provisions for follow-up should be made. If the dyad is making progress at home, telephone conversations or secure video conferencing, text messaging, or email (through special applications) may be sufficient follow-up. If the care plan is not having the desired results or is difficult for the family to implement, a return visit is warranted.

A firm background in both the individual components and the gestalt of normal feeding is required for lactation consultants working with infants who have sucking difficulties. Providing normal cueing in the form of ideal positioning and skin-to-skin contact with the mother is the first step to promoting normal feeding. Next, compensatory and facilitative strategies are applied as probes and added to the feeding plan if they are effective and well-tolerated by both mother and infant. If normal feeding is not restored by these interventions, the infant should be referred to a feeding team for further evaluation.

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