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Feeding and Swallowing Development in Children

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Feeding and Swallowing Development in Children: A Literature Review

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Abstract

The feeding and swallowing developments are involved in maturation of anatomy, food textures, and utensils. As children grow, the dependence of feeding moves to self-feeding. Understanding and educating individuals about feeding and swallowing development is critical. The knowledge of feeding and swallowing development can help parents support nutrition and growth in their children by learning timelines and normal feeding and swallowing expectations. This project is to provide clinical resources in order to assist in providing proper care for patients, recognizing signs demonstrating difficulty swallowing, and implementing appropriate self-feeding and consistency development timetables. Caregivers and clinicians will benefit from this information.

Introduction

Every day, individuals swallow around 1000 times. This means that every decade, individuals swallow about 3 to 4 million times (Dodds, 1989). This high prevalence of swallowing indicates the necessity of understanding what all goes into this process. Swallowing involves precise execution of movements in order to bring food from the mouth to the stomach (Arvedson et al., 2020; Miller, 1986). To start the process, food and saliva combine in the mouth (Allaire & Stevenson, 1991). Throughout, voluntary and involuntary movements are coordinated while sensory information is being sent back (Allaire & Stevenson, 1991). When swallowing, specific timing is needed at all phases in order for a safe and effective swallow (Nishino, 2013). In the end, the basic functions of swallowing are for weight gain, nutrition, and hydration (Arvedson et al., 2020).

There are swallowing differences that can be seen between children and adults (Arvedson et al., 2020). Understanding the pertinent information about normal swallowing development will benefit both caregivers and clinicians. Individuals swallow every day and being educated on normal swallowing will assist in providing proper care for patients, implementing appropriate self-feeding and consistency development timelines, and recognizing signs that may suggest difficulties with swallowing. This knowledge is valuable and something that should be discussed in further detail for more learning opportunities. The four parts are considered for development: anatomy, physical, cognitive, and emotional. Anatomy and physical related to feeding and swallowing will be discussed in more detail. Each varies by individual. One way to understand swallowing is by diving deeper into anatomical structures and feeding and swallowing developmental milestones.

Oral Reflexes

There are numerous oral reflexes that are associated with swallowing and some can appear before and after birth. The earliest reflex to develop is the gag reflex and that is seen by 26-27 weeks' gestation (Arvedson et al., 2020). This is when the pharynx contracts and the tongue protrudes. Individuals never outgrow this reflex and therefore, adults still have their gag reflex. Following that, reported by 28 weeks' gestation is the rhythmic closing (phasic bite) and tongue reflexes. This is where the jaw opens and closes rhythmically, and it disappears around 9-12 months. Tongue protrusion occurs because of the front of the tongue being touched. By 4-6 months, the reflexes disappear. The tongue transverse reflex allows the tongue to move to the stimulated side and diminishes by 6-9 months (Arvedson et al., 2020). Eventually, the rooting reflex is present. This reflex allows infants to turn their head in the direction of the side that is being stimulated (Arvedson et al., 2020). This typically disappears by 3-6 months (Arvedson et al., 2020). Additionally, mouthing is when infants put any objects within reach in their mouth, and this is predominantly during the first 4 to 5 months (Morris & Klein, 2000). Finally, the swallowing reflex as a whole is known as a "defensive reflex" due to the importance of guarding the airway (Nishino, 2013). This reflex is a result of the bolus hitting the pharynx area (McCarthy, 2006).

Anatomy of Swallowing

Swallowing involves various anatomical structures. Arvedson et al. (2020) and Bosma (1986) stated that 31 coordinating muscles, the central nervous system, and six cranial nerves are all needed for normal swallowing. Along with this, there are major anatomy structures that are involved (Arvedson et al., 2020). The nose is primarily necessary for inhalation and exhalation. It also makes up the nasal cavity that is protected by the soft palate when swallowing. The oral cavity consists of mouth structures (i.e. lips, mandible, tongue) and they are used to form a bolus and to bring it toward the pharynx (Arvedson et al., 2020). While in the oral cavity, glands produce saliva

to mix with the food to form a bolus that moves to the pharynx (Phillips & Zieve, 2019). The pharynx is made up of the nasopharynx, oropharynx, and hypopharynx (Arvedson et al., 2020). The nasopharynx is above the oropharynx and behind the nasal cavity. One of its primary duties is to produce resonance for appropriate speech. The oropharynx consists of the epiglottis and valleculae and it is in between the nasopharynx and hypopharynx. The hypopharynx is below the oropharynx (at the point of the hyoid bone) and it moves the bolus down to the stomach using pharyngeal constrictors and peristaltic waves. The pharynx stretches to make more space as a child develops. The larynx protects the airways and it is necessary for an individual's voice and breathing (Arvedson et al., 2020). In particular, the true and false vocal folds are contained within the larynx. Finally, the esophagus brings the food to the stomach. As a result of all these structures, respiration, phonation, and swallowing can occur (Arvedson et al., 2020).

Development of Swallowing Anatomy

Swallowing structures have anatomical differences through development when comparing an infant and older child (Arvedson et al., 2020). Anatomy changes occur with age, meaning the anatomy of an infant versus an older child is distinguished by changes due to development (Lefton-Greif, 2010). Furthermore, swallowing adapts to the anatomic changes that occur, specifically the anatomy of the pharynx, and to keep up with developmental skills (Lefton-Greif, 2010). Infants have a much smaller mouth and therefore, the tongue takes up most of the capacity of the mouth (Arvedson et al., 2020). Infants are edentulous, while older children are dentulous. As individuals get older, the tongue lies at a lower position (floor of the mouth) since the mouth is bigger and the tongue sits behind the teeth. In addition, infants are designed to suck by using their tongue, sucking pads, and sulci. As individuals become older, cheek muscles such as buccinators, are used because of maturity. As the cheek muscles mature, the sucking pads are not necessary anymore and so they

degenerate. As expected, the mandible develops in infancy into childhood to be at a typical jaw size. Infants do not have a distinct oropharynx and as they develop, the pharynx is lengthened vertically. The nasopharynx becomes a 90-degree angle and the epiglottis becomes wide and flattened. In infancy, the size of the larynx is 1/3 of an adult larynx (Arvedson et al., 2020). Arvedson et al. (2020) and Caruso & Sauerland (1990) state this causes the base of the tongue to be close to the larynx and it separates at around age 4. Older children have true vocal folds that consist of no more than 1⁄3 of cartilage compared to 1/2 in infancy (Arvedson et al., 2020). Lastly, the larynx is located higher in the laryngeal cavity until age 2 when it starts to lower. Moreover, proportions differ, resulting in differences in swallowing development (Morris, 1990). For example, the jaw is small and so the oral cavity is also small. Sucking pads give stability. The epiglottis and soft palate touch when at rest for an alternative (Morris, 1990). Additionally, there are a few milestones that span across multiple months. Over time, the mandible extends down and forward, the oral cavity expands, the hyoid and larynx are positioned further down, and sucking pads are gone (Arvedson et al., 2020). This causes differences in breathing and swallowing so that there is proper coordination and reciprocity between the two (Arvedson et al., 2020). Teeth are needed in the feeding process as well. They start to come in between 6-24 months, and all should appear by the beginning of 3 years old. The munching stage occurs because children do not necessarily need teeth for chewing at this point. Munching is when the child's jaw moves up and down while chewing. As children mature, the tongue pushes the food laterally to chew with their teeth (Arvedson et al., 2020). Arvedson et al. (2020) and Vitti and Basmajian (1975) state by 3-6 years in age, mature chewing is noted. Also, children go from vertical movement to their jaw moving in a grinding motion (Arvedson et al., 2020). Furthermore, a study from Carruth et al.

(2004) looked at infants 4 to 24 months old and it revealed the necessity of the development of teeth and the correspondence to consistency development.

Figures 1 and 2. Anatomical swallowing differences for infant versus older child.

Figure 1

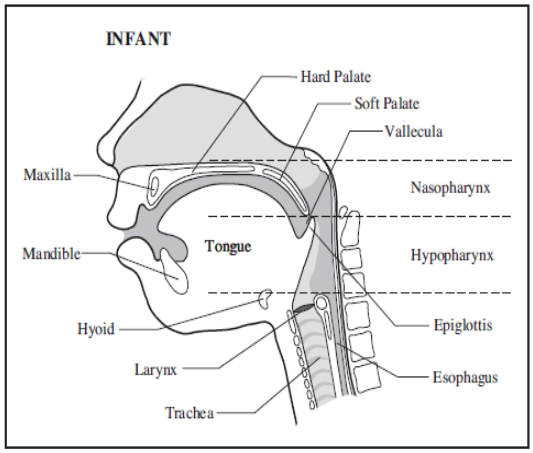
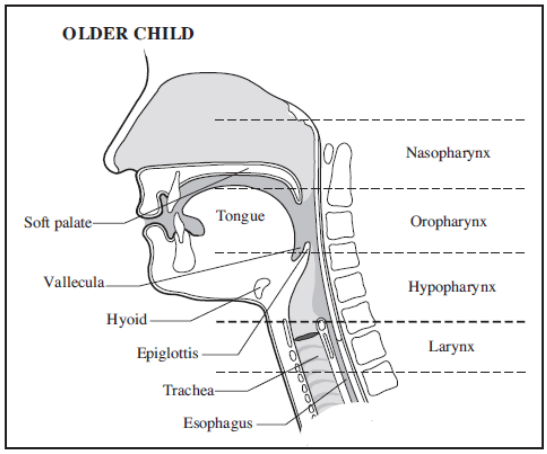


Figure 2



Note. The figures illustrate the development of swallowing anatomy. Reprinted from *Pediatric Swallowing and Feeding Assessment and Management* (3rd ed., p.12 and 14), Copyright 2020 by Arvedson et al.

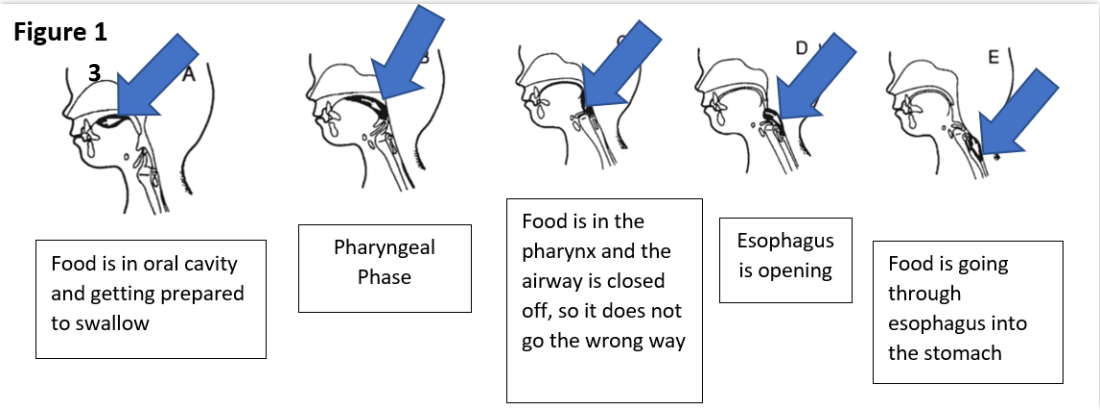
Swallowing Phases

There are four phases that occur during swallowing: oral preparatory, oral phase, pharyngeal phase, and esophageal phase (ASHA, n.d.). The distinction between phases is dependent upon where the bolus is located (Matsuo & Palmer, 2008; Dodds et al., 1990; Logemann, 1998). Furthermore, each phase has a certain function, and recognizing what qualifies as a normal swallow is important. The oral preparatory phase prepares the food and manipulates it into a bolus (Dodds, 1989). This involves mixing with saliva, chewing, and moving it to the

appropriate location to be transferred (Dodds, 1989). Preparing solids involves more exertion and this requires assistance from the teeth to form a bolus (Allaire & Stevenson, 1991). The bolus is presented to the oral cavity and lip seal is noted in order to prevent spillage (The Four Phases, n.d.). During the oral phase, the tongue tip is up against the alveolar ridge and the bolus is positioned behind this without spillage into the sulci or pharynx (Dodds, 1989). Dodds (1989) and Ramsey et al., (1955) say that the tongue lifts up and creates a peristaltic motion and this causes the bolus to move backwards. At this point, the soft palate rises and touches the posterior pharyngeal wall to block the bolus from going into the nasal cavity causing nasal regurgitation (Dodds, 1989). The thicker the bolus, the more muscles that are required during this time (The Four Phases, n.d.) The oral phase can take about 0.7 to 1.2 seconds (Dodds, 1989). However, this phase is also known to take 1 to 1.5 seconds (The Four Phases, n.d.). During the pharyngeal phase, numerous physiological occurrences are noted (The Four Phases, n.d.). This can include laryngeal elevation, contraction of the false vocal folds and true vocal folds, and the epiglottis inversion (The Four Phases, n.d.; Logemann, 1998). Breathing ceases to protect the airway as well (Arvedson et al., 2020). The pharyngeal phase causes the pharyngeal constrictors to assist in pushing the bolus down while hyoid excursion and elevation of the larynx occurs. The UES opens at this time as well (Arvedson et al., 2020). Typically, it takes about 0.6 seconds (Dodds, 1989). The esophageal phase transports the bolus all the way down to the stomach by peristaltic waves (Arvedson et al., 2020). In order for the bolus to be completely out of the esophagus, it typically takes about two waves (The Four Phases, n.d.). According to Dodds et al. (1973, 1989) and lngelfinger (1958), this takes about 6 to 10 seconds. It is also known to take 8 to 20 seconds in its entirety (The Four Phases, n.d.). Overall, cranial nerves are used throughout this process (V, VII, IX, X, XII) and

sensory receptors provide sensory information regarding bolus size and consistency during the swallow (Dodds, 1989).

Figure 3. Process of Normal Swallowing.



Note. The figure illustrates the process of normal swallowing and what occurs. Adapted from *Pediatric Swallowing and Feeding Assessment and Management* (3rd ed., p.34), Copyright 2020 by Arvedson et al.

Swallowing Variations Between Child and Adult

The oral preparatory phase is impacted by the swallowing variations between a child and adult. Preparing food to swallow is different (Beecher & Alexander, 2004). Infants are either breast or bottle fed, and they go from suckling to sucking (Arvedson et al., 2020). The pressure is built up inside the oral cavity and at the same time, infants are trying to decipher when they need to swallow and when they need to breathe. This leads to infants having a suck swallow ratio (Arvedson et al., 2020). Typically, they have between one and three sucks before a swallow. As maturation occurs, a one-to-one ratio is observed (Arvedson et al., 2020). In addition, the type of food and size can impact the oral preparatory phase (Brindo & Maxbauer, 2017). For example, a big chewy piece of steak will take longer to prepare to swallow than a small piece of cracker. The

oral, pharyngeal, and esophageal phases differ as well. When looking at timing differences between infants and adults, an increase in the initiation time and bolus transition time can be seen (Brindo & Maxbauer, 2017; Tracy et al., 1989; Shaw et al., 1990, 1995; Robbins et al., 1992; Soergel, 1964). Therefore, this means that adults have longer transition times and children have shorter times. In addition, the larynx and hyoid are located higher for more airway protection (Morris, 1990).

Feeding

Feeding is the process for intake of food, including placing the food in the mouth (Beecher & Alexander, 2004). It is a dynamic progression involving feeding changes that can occur from experience and maturation (Allaire & Stevenson, 1991). Over time, anatomic structures grow, and the location of the structures move, and which causes the function of each structure to be impacted (Allaire & Stevenson, 1991). Major functional influences on feeding include respiratory function for breathing, oral function for sensitivity to food, pharyngeal function for airway protection, and the gastrointestinal system in order to digest food (Beecher & Alexander, 2004). A function of the feeding process involves the interactions of a variety of factors like the child's environment, caregiver-child interaction, and medical and developmental status (Beecher & Alexander, 2004). Understanding the development of feeding skills in children is critical. As feeding skills improve, food consistencies and feeding methods develop as well (Arvedson et al., 2020; Pridham, 1990). The knowledge of feeding skill development will assist in deciding the readiness for self-feeding and food types so that there is proper nutrition and hydration (United States Department of Agriculture Food and Nutrition Services, 2009). The progression can be different from child to child depending on their skills. Having an idea about what feeding skills should be seen and when,

will support growth in children (United States Department of Agriculture Food and Nutrition Services, 2009).

Feeding and Swallowing Development

When understanding the swallowing and feeding process, major developmental milestones should be noted. As infants mature, they develop movements and skills that assist in their feeding abilities (Arvedson et al., 2020). The feeding progression can differ depending on the source. Arvedson et al. (2020) suggest that within the first month, milestones include the ability to suckle and breathe from their nose. Suckling is when the tongue moves horizontally and in and out (Arvedson et al., 2020). It is important to note that the amount of suckling increases with age. Also, during the 1st month, sustained flexed limbs are noted and this allows for a position that is adequate for feeding. However, lip closure is inadequate (Arvedson et al., 2020). Arvedson and Lefton-Greif (1996) state from 0 to 4 months is when suckling is seen. Arvedson et al. (2020) states that at 2 months, the presence of jaw movement, suckling pattern, and lip closure is observed. At 3 months, neck flexion occurs. Infants at 4 months old have the capability of moving their mouth with a purpose and distinguishing the lip from their tongue. Nipple attachment is improved, and a sucking pattern develops at 5 months. Unlike suckling, sucking is when the tongue moves vertically and up and down (Arvedson et al., 2020). At 6 months, infants should have tongue movements in all directions, teething occurs, and lip closure is for a longer time period (Arvedson et al., 2020). On the other hand, Arvedson and Lefton-Greif (1996) states that from 4 to 6 months is the transition from suckling to sucking. Arvedson and Lefton-Greif (1996) also states that vertical munching with few occurrences of lateral tongue movement is noted at 6 to 9 months. Arvedson et al. (2020) says that starting between 7 to 9 months, the mouth is used as an investigative measure and the lip is used to clear the spoon. It is noted by Arvedson et al. (2020)

and Pridham (1990) that by 8 months, the suck and swallowing abilities are strong enough to adequately get nutrition orally. From 10 to 12 months, there is coordination of the lip, tongue, and jaw movement. There is also an up and down and diagonal jaw movement present. From 13 to 18 months, infants figure out how to move their lips and appropriately swallow and breathe. Ages 19 to 24 months is when there is precise movements of the tongue, rotary chewing, and lip closure that occurs during swallowing all observed (Arvedson et al., 2020). It is important to note that Arvedson and Lefton-Greif (1996) declare that it is not until 12 to 18 months that lateral tongue movement is more prevalent and rotary chewing follows by 24 months. Finally, from 24 to 36 months, the jaw moves in circulatory rotation and lip closure is sustained during chewing (Arvedson et al., 2020).

Self-Feeding Development

The milestones and differences seen in children play a role in self-feeding development. The self-feeding development stages go from no self-feeding, self-finger feeding, predominantly self-feeding with spillage, and then total self-feeding without spillage (Arvedson et al., 2020). Self-feeding is related to the ability to sit, recognize objects, and the ability to pick objects up (Arvedson et al., 2020). These self-feeding milestones also demonstrate the importance of trunk and head control and eye-hand coordination that mature over time (Arvedson et al., 2020; Delaney & Arvedson, 2008). In particular, from 0 to 4 months, head control emerges (Arvedson & Lefton-Greif, 1996). 4 to 6 months is when sitting on one's own is feasible. From 6 to 9 months, finger feeding starts, and the child can pinch items in order to grasp it. This progresses to using the entire hand to hold the spoon from the ages of 9 to 12 months. 12 to 18 months is when independent feeding skills are more prevalent (Arvedson & Lefton-Greif, 1996). Carruth et al. (2004) examined infants 4 to 24 months old in which parents were interviewed about ages of dentition,

developmental milestones, gross motor development, and self-feeding skills. Timelines of these four areas were recorded, however, variability can be seen in these milestones and this should be accounted for when reviewing the results. In particular, milestones for gross motor skills demonstrated the necessity of head and trunk stability for self-feeding. This led to self-feeding being investigated by looking at the ability for the child to use their hands to grasp food, usage of lips as a spoon clearing method, spoon-feeding with limited spillage, sippy and regular cup usage, and chewing capabilities. They reported that developmental readiness noted at an earlier age, can lead to higher amounts of necessary nutrients and energy. But by 15 to 18 months, self-feeding skills seem to be about the same no matter what age the children were introduced to self-feeding. Also, the older children get, the more these skills mature (Carruth et al., 2004).

Consistency Development

The consistency that a child consumes develops over time as well. There can be many references that vary on this development. Starting at birth, milk is given to infants through bottle or breast feeding. Liquid is the primary consistency from 0 to 4 months (Arvedson & Lefton-Greif, 1996; Arvedson et al., 2020). Arvedson and Lefton-Greif (1996) and Arvedson et al. (2020) observe that purees are introduced from 4 to 6 months old. Yogurt in milk and infant foods are considered liquid/puree (Hall, 2001). Food consistency variations can be evident and McCarthy (2006) states from 4 to 6 months old, foods like oatmeal, mashed banana, and sweet potato can be given. McCarthy (2006) notes that between the ages of 5 to 7 months, peaches, peas, or wheat can be introduced. It is also known that from 6 to 12 months, thicker or lumpier food can be implemented (Arvedson et al., 2020; Pridham, 1990). It is crucial to note that there is a sensitive period for children that is predominately at about 6 months old (Arvedson et al., 2020). This is a significant time to introduce chewable texture to children because during this time, they are more

inclined to learn and do the desired activity (Arvedson et al., 2020; Illingworth & Lister, 1964). If the child is introduced after this time, it is harder for them to learn to chew solids and textures are harder to tolerate (Arvedson et al., 2020). It is recommended that foods should be introduced one at a time (Arvedson et al., 2020; Fomon, 2001a, 2001b; Fiocchi et al., 2006). At 6 months old, semi-solid food can be consumed (Arvedson et al., 2020). Semi-solid food includes pureed fruit in juice, soft noodles, or crumbs from crackers (Hall, 2001). McCarthy (2006) finds that from 6 to 8 months can include foods like plain yogurt and whole wheat bread and from 8 to 10-month-old children have noodles and broccoli. Arvedson and Lefton-Greif (1996) states soft chewables are the normal consistencies being fed from 6 to 9 months old. Cottage cheese, lean beef, and avocado are examples of foods given between 7 to 9 months (McCarthy, 2006). On the other hand, Arvedson and Lefton-Greif (1996) state that lumpy puree foods are introduced at 9 to 12 months. For examples, meats like pork and chicken with vegetables can be implemented (McCarthy, 2006). Arvedson et al. (2020) says from 13 to 18 months, various textures can be introduced, and implementation and adaptation of various textures should be seen from 19 to 24 months. This can consist of cookies, pasta, and mashed potatoes (Arvedson, 2014). Finally, 24 to 36 months is when solids can be introduced (Arvedson et al., 2020). This can be anything chewy or even uncooked vegetables (Arvedson, 2014). Arvedson and Lefton-Greif (1996) agrees that the next level of consistency is chewier foods and then at 24 months the child can have hard solids. These examples of consistencies are all meant to provide adequate nutrition. The balance of a healthy diet is a factor that plays a role and focusing on the calorie intake is crucial in infants (McCarthy, 2006).

The consistency development has many variations, but it is also important to recognize that each child is unique and can have factors that play a role (Arvedson et al., 2020). Individual variations can be seen due to culture and socioeconomic status. Where parents are from and the

resources parents have can impact a child's outcome. It is imperative to consider each individual as a whole and to individualize each plan in order to support growth through proper nutrition and hydration.

Feeding Utensil Development

The development of feeding utensils is important. Children go from breast or bottle feeding, to spoon feeding, to cup drinking, to finger feeding, to fork feeding, to regular cup drinking (Arvedson et al., 2020). When an infant is being bottled or breast fed, suckling is noted due to a small oral cavity and this moves to a suck at 6 months (Arvedson et al., 2020). The nipple of a bottle can be adjusted to account for sucking patterns and characteristics of the infant's mouth (i.e. size) (McCarthy, 2006). The ability for an infant to breathe and suck is a skill that is necessary, and this develops with age (Arvedson et al., 2020). As infants eat, they breathe through their nose and this stops while in the pharyngeal phase. At around 4 to 6 months, transitional feeding occurs, and the child is engulfed in spoon feeding. A month after that, the child begins cup drinking (Arvedson et al., 2020). Cups can control the flow and can be adjusted depending on the size of the child and the amount of liquid needed (McCarthy, 2006). Do not be alarmed if the child seems to digress when introducing them to a new feeding method (Arvedson et al., 2020). This is typical until they learn the new method that is being presented (Arvedson et al., 2020). After 6 months, children understand that they can eat food with a spoon, they can munch with thicker foods, and fingers, spoons, or cups are the methods for self-feeding at this time. Their tongues become more flexible and they are able to vocalize and physically demonstrate their desire to be fed (Arvedson et al., 2020). It is not until 7 to 9 months that the upper lip properly seals against the spoon to clear it. From 24 months, open cup drinking is noted, and no spillage should be apparent (Arvedson & Lefton-Greif, 1996). In addition, forks are utilized at this time (Arvedson et al., 2020).

Conclusion

Understanding the structural progression, normal swallowing development, self-feeding development, consistency development, and feeding utensils development in infants versus older children can be useful knowledge for parents and clinicians. This knowledge can help parents support nutrition and growth in their children by learning timelines and normal feeding and swallowing expectations. In addition, the understanding has clinical implications for clinicians. Clinicians will have a better grasp of what proper nutrition and growth is appropriate and they can relay the information in a more parent-friendly manner to the parents. Speech-language pathologists can also develop their clinical proficiency and decision-making skills with this information in order to best support all clients.

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