Feeding problems are a prominent developmental issue for preterm infants (Lau & Hurst, 1999; Ross & Browne, 2002). An important aspect of nutritive feeding in preterm infants is coordination among the processes of suck, swallow, and respiration. Compromise of this coordination can result in suboptimal nutrition and growth. Nutritive sucking is a complex process that allows in-depth examination of the integration of neonatal behavioral organization (Bu’Lock, Woolridge, & Baum, 1990; Conway, 1994). Sucking may be a sensitive indicator of central nervous system integrity, differentiating stressed from nonstressed infants even when standard neurological examinations fail to do so (Martell, Martinez, Gonzalez, & Diaz Rossello, 1993; Medoff-Cooper, McGrath, & Bilker, 2000). Moreover, sucking rhythms are useful clinically in discriminating infants with a history of perinatal complications but with no abnormal neurological signs and infants with a benign perinatal history (Drillen, 1972).

Different types of nutritive sucking have been described using the sucking rhythm as the differentiating criterion (Gewolb, Bosma, Reynolds, & Vice, 2003; Glass & Wolf, 1994; Gryboski, 1969; Medoff-Cooper, Weininger, & Zukowsky, 1989; Meier & Anderson, 1987; Palmer, 1993). Sucking patterns can be labeled as immature, transitional, and mature. The immature sucking pattern (3–5 sucks per burst) has been observed in premature infants as early as 32 weeks and 3 days (Gryboski, 1969; Meier & Anderson, 1987). The transitional sucking pattern is described as a burst–pause pattern, with typical sucking bursts of 6–10 sucks per burst (Palmer, 1993). The mature sucking pattern is characterized by sucking bursts of 10–30 sucks per burst with only brief pauses between bursts (Medoff-Cooper, McGrath, & Bilker, 2000).
Cooper et al., 1989). The mature sucking pattern is usually observed in infants after 40 weeks’ gestational age and has been used as one of the criteria to assess an infant’s oral–motor skills. An infant’s failure to demonstrate mature sucking after a certain age is considered a soft neurological sign (Palmer & Heyman, 1999).

Infants with bronchopulmonary dysplasia (BPD) have difficulty achieving coordinated suckle feeding (Gewolb et al., 2003) and demonstrate irregular breathing patterns during feeding (Craig, Lee, Freer, & Laing, 1999). Successful feeding is further compromised by acute oxygen desaturation during feeding (Garg, Kurzner, Bautista, & Keens, 1988; Singer et al., 1992). The goal of the present study was to compare the differences in bottle-feeding behaviors in infants with and without BPD during the initial hospitalization. We examined the feeding history of a sample of preterm infants through medical chart review. We hypothesized that infants with BPD would show less mature sucking patterns and would require more time and feeding assistance to finish their feedings compared to infants without BPD.

Methods

This retrospective study was conducted at Mount Sinai Medical Center in New York City with the approval of the hospital’s institutional review board. We reviewed all medical charts in the neonatal intensive care unit (NICU) from July 2001 to July 2003. Infants who met all of the following criteria were included in this study: Infants (a) were born at a gestational age of less than or equal to 34 weeks; (b) were free from any major cardiac, gastrointestinal, or congenital impairment; (c) had received occupational therapy services during their NICU stay; and (d) were fed by bottle with or without breast feeding experience during the hospital stay. *Bronchopulmonary dysplasia* was defined as an oxygen requirement at more than 28 days of life. Infants who had a tracheotomy or who were discharged home with a nasogastric tube were excluded from this study.

The data were originally collected for a longitudinal study to examine the factors related to bottle feeding in preterm infants (Howe, 2004). Thirty-four infants with a birthweight greater than 1,500 g who had been excluded from the previous data set were included in the present study.

Each infant’s medical chart was reviewed for information at two time points. The first observation occurred shortly after bottle feeding was initiated (between 1 and 5 days) and the second just before discharge (within 5 days). We obtained data from a detailed review of occupational therapy progress reports included in the medical records. The variables we examined included sucking patterns, sucking characteristics, transitional rate, oral feeding assistance, and duration of hospital stay, among other factors. The transitional rate was calculated by the ratio of feeding intake (ml) to the feeding duration (min). The volume of milk was the amount of milk that the infant had consumed via bottle at observed feed. The time was measured as soon as the bottle was introduced and sucking began. Any interruptions, such as burping, and allowance for breathing during feeding were included as part of feeding. The time was recorded when the infant finished his or her required amount or stopped sucking for more than 2 min. Oral feeding assistance was defined as any external assistance applied by a feeder to an infant during bottle feeding to facilitate performance. In this study, oral feeding assistance included oral support and external pacing.

The Neonatal Oral Motor Assessment Scale (NOMAS; see Figure 1) was included as part of the feeding assessment in the occupational therapy progress report (Braun & Palmer, 1986; Palmer, Crawley, & Blanco 1993), and written permission was obtain from Ms. Palmer.

In line with hospital protocol, an occupational therapist routinely monitored each infant when the infant was medically stable and when his or her feeding delivery method had progressed from continuous feeding (the default method for infants weighing less than 1,250 g) to bolus feeding. A single occupational therapist (the first author) implemented the feeding assessment and intervention for all infants in the NICU.

Results

We reviewed the records of 140 premature infants (66 boys, 74 girls), 41 in the BPD group and 99 in the non-BPD group. Characteristics of infants in the BPD and non-BPD cohorts are given in Table 1. Infants in the BPD group tended to be of lower birthweight and lower gestational age than those in the non-BPD group. Both groups started oral feeding at a similar age and weight. Consequently, the postnatal age (days of life) at time of first observation was significantly higher in the group with BPD ($p < .001$).

We compared the infants’ feeding behaviors on discharge using records of the last feeding observation. Table 2 allows comparison of the BPD and non-BPD group. On discharge, the majority of infants in both groups did not demonstrate a mature sucking pattern (85% in the non-BPD group and 93% in the BPD group). Seventy percent of infants in the non-BPD group and 54% of infants in the BPD group demonstrated the transitional sucking pattern. When we examined developmental sucking patterns, we found that infants with BPD who demonstrated the transitional sucking pattern on discharge were significantly older.
than those in the non-BPD group (37.5 weeks vs. 35.6 weeks; \( p < .001 \)). In addition, infants with BPD achieved full oral feeding significantly later than their counterparts (38.5 weeks vs. 35.5 weeks). No significant differences were found in the areas of feeding assistance and practice.

### Discussion

In our study, most infants in both groups did not demonstrate a mature sucking pattern (i.e., continuous sucking bursts) when they were discharged from the NICU. This

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**Figure 1. Neonatal Oral Motor Assessment Scale.**

- **Jaw**
  - **Normal**
    - Consistent degree of jaw depression
    - Rhythmic excursions
    - Spontaneous jaw excursions occur upon tactile presentation of the nipple up to 30 minutes prior to a feed
    - Jaw movement occurs at the rate of approximately one per second (1/2 the rate of NNS)
    - Sufficient closure on the nipple during the expression phase to express fluid from the nipple
  - **Disorganization**
    - Inconsistent degree of jaw depression
    - Arrhythmic jaw movements
    - Difficulty initiating movements:
      - Inability to latch on
      - Small, tremor-like start-up movements noted
      - Does not respond to initial cue of nipple until jiggled
    - Persistence of immature suck pattern beyond appropriate age
      - Under 40 weeks PC (transitional suck)
  - **Dysfunction**
    - Excessively wide excursions that interrupt the intra-oral seal on the nipple
    - Minimal excursions; clenching
    - Asymmetry; lateral jaw deviation
    - Absence of movement (% of time)
    - Lack of rate change between NNS and NS (NNS
      - \( \text{NS} = 2/\text{sec}; \text{NS} = 1/\text{sec} \))

- **Tongue**
  - **Normal**
    - Cupped tongue configuration (tongue groove) maintained during sucking
    - Extension-elevation-retraction movements occur in anterior-posterior direction
    - Rhythmic movements
    - Movements occur at the rate of one per second
    - Liquid is sucked efficiently into the oropharynx for swallow
  - **Disorganization**
    - Excessive protrusion beyond labial border during extension phase of sucking without interrupting sucking rhythm
    - Arrhythmic movements
    - Unable to sustain suckle pattern for two minutes due to:
      - Habituation
      - Poor respiration
      - Fatigue
    - Incoordination of suck/swallow and respiration which results in nasal flaring, head turning, extraneous movement
  - **Dysfunction**
    - Flaccid; flattened with absent tongue groove
    - Retracted; humped and pulled back into oropharynx
    - Asymmetry; lateral tongue deviation
    - Excessive protrusion beyond labial border before/after nipple insertion with out/down movement
    - Absence of movement (% of time)

**Summary and impression**

Recommendations:

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**Certified Examiner**

Certificate #__________

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finding is not surprising, because neither group had reached a gestational age of 40 weeks when discharged from the hospital. With further examination, we found that infants with BPD demonstrated a lower sucking rate and showed slower progression through sucking patterns. These results confirm other findings that infants with BPD do not follow predicted maturational patterns of suck–swallow rhythmic integration (Gewolb et al., 2003; Gewolb, Bosma, Taciak, & Vice, 2001). Researchers have used sucking rhythms as an indicator of maturation in neurobehaviors in preterm infants (e.g., Medoff-Cooper et al., 2000). In our study, infants with BPD failed to demonstrate age-appropriate sucking patterns, indicating signs of immaturity compared with their counterparts.

Oral support was reported to be effective in improving preterm infants’ sucking efficiency (Einarsson-Backes, & Vice, 2001). Researchers have used sucking rhythms as an indicator of maturation in neurobehaviors in preterm infants (e.g., Medoff-Cooper et al., 2000). In our study, infants with BPD failed to demonstrate age-appropriate sucking patterns, indicating signs of immaturity compared with their counterparts.

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In our study, we found that techniques used to assist oral feeding, such as oral support and external pacing, were similar for healthy premature infants and infants with BPD. Infants with BPD did not require more feeding assistance, as we had originally hypothesized. Thus, prematurity, rather than chronic lung problems, appeared to be the reason for needing oral support during feeding, as BPD was not a contributing factor.

We compared characteristics of feeding behaviors listed in the NOMAS between groups. None of the behavioral indicators (e.g., arrhythmic tongue or jaw movements) were found to be significantly different between BPD and non-BPD groups. This finding does not support Perlman and Volpe’s (1989) observations of abnormal tongue and jaw movements in 10 preterm infants with BPD during feeding. Further research should map out feeding behaviors as a function of age.

This study had two limitations. First, the data collection was limited to the time of infants’ initial hospitalization; therefore, examination of feeding performance after discharge was not possible. Future research should compare the feeding performance of BPD and non-BPD groups in long-term follow-up. Second, infants who had severe feeding problems were not included in this study. The infants in our sample thus may not be representative of all premature infants, especially those who need a nasogastric tube for nutrient supplement at the time of discharge.

As a general policy at our institution, to be considered as functional feeders and to be discharged home with full oral feeding, infants are required to finish all feedings within 30 min without any cardiorespiratory compromises. We found that infants with BPD required a longer hospital stay to attain full oral feeding.

On the basis of these data, we suggest that a clinical decision to discharge infants with BPD home without alternative feeding intervention (i.e., nasogastric tube placement) should rely more on feeding transitional rate than sucking pattern. The ability to consume the required amount of milk within a reasonable time is a stronger indicator of function.

Findings from this research are important to clinicians working in NICUs. The development of effective strategies to ensure an infant’s ability to consume the required amount of milk within a reasonable time is critical in the facilitation of discharge plans. This goal is commonly achieved in two ways in clinical practice. First, an infant’s feeding time can be shortened by decreasing the required amount of milk per intake. For example, the caloric density for breast milk and infant formulas, unless specifically noted, is 20 kcal/30 ml. A total requirement of 120 kcal/kg/day for a 2,000 g infant (240 kcal) can be reached with 60 ml of formula per feeding (40 kcal) every 4 hr (6 feedings). By increasing the caloric density to 24 kcal/30 ml, the infant needs to take only 50 ml per feeding to reach the same caloric requirement (240 kcal/6 feedings/24 kcal × 30 ml). The amount of milk per intake can be manipulated accordingly. However, therapists must work closely with medical teams, including dieticians, to maintain an infant’s caloric intake and fluid requirements while decreasing the amount of milk per feeding. Each infant should be assessed individually to achieve a balance between volume intake per feeding and feeding time needs before discharge.

Second, a nipple with a higher flow can shorten an infant’s feeding time. Increased free flow of formula through the nipple can increase ingestion rate, and using nipples designed for premature infants may encourage volume intake (Medoff-Cooper et al., 1989; Schrank, Al-Sayed, Beahm, & Thach, 1998). However, therapists need to exercise caution with nipple selection. An infant’s ability to handle milk flow, behavior state during feeding, and individual feeding style must be considered during the selection process (Lau & Schanler, 2000).

Conclusion

In the NICU setting, occupational therapists play an important role in supporting the normal development of feeding and providing parent education (Caretto, Topolski, Linkous, Lowman, & Murphy, 2000; Matthews, 1994). Therapists should not only assess an infant’s sucking abilities but also provide feedback on feeding strategies to primary caregivers, including medical staff and parents. Treatment sessions should involve parent and caregiver education and hands-on practice. Therapists who choose to use milk transitional rate as a functional guide in choosing feeding strategies should educate parents about this concept to ensure postdischarge follow-through.

To formulate a functional treatment plan, occupational therapists directing the care team in decision making about appropriate and effective feeding strategies for each infant should incorporate feeding-related input from all team members. They also should promote primary caregivers’ understanding of the reasons for specific feeding strategies. In so doing, they will contribute to greater compliance with strategies after discharge and thus ensure a safer and more successful discharge plan. ▲

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References


