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# Oral stimulation techniques in preterm infants – International research challenges<sup>☆</sup>

Zelda Greene<sup>a,\*</sup>, Colm P.F. O'Donnell<sup>b</sup>, Margaret Walshe<sup>c</sup>

<sup>a</sup> *Speech and Language Therapy Department, Our Lady's Children's Hospital, Crumlin, Dublin 12, Ireland*

<sup>b</sup> *Neonatology Department, The National Maternity Hospital, Holles Street, Dublin 2, Ireland*

<sup>c</sup> *Clinical Speech and Language Studies, Trinity College Dublin, Dublin 2, Ireland*

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**Abstract** There has been a significant increase in the survival of preterm infants in recent years. These infants often face difficulty acquiring the complex set of skills required for exclusive oral feeding due to a multiplicity of factors. This paper discusses the theory underlying the use of oral stimulation interventions with the preterm infant, and their role in facilitating the transition from tube (gavage) feeds to exclusive oral feeding and ultimately discharge from the Neonatal Intensive Care Unit. Oral stimulation interventions are defined and the range of interventions described in the current literature is examined. The challenges that exist in deciphering the research evidence supporting their use is explored and directions for future research are provided.

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## Introduction

The complex skills, required for the development of sucking and feeding in infants, have been well documented (Bingham et al., 2010; Dodrill et al., 2008a; Pickler et al., 2006; Poore and Barlow,

2009). For the preterm infant acquisition of these skills means dealing with many added challenges depending on the extent of the prematurity and the myriad of accompanying co-morbidities and experiences encountered on the journey through the Neonatal Intensive Care Unit (NICU). Many multidisciplinary team members are involved in helping the preterm infant navigate through the NICU and often the ability to feed orally determines discharge from the unit. Early discharge from NICU has financial implications for healthcare providers. Figures from the United States estimate

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\* Corresponding author. Tel.: +353 1 409 6198.

E-mail addresses: [zeldagreene@gmail.com](mailto:zeldagreene@gmail.com), [zelda.greene@olchc.ie](mailto:zelda.greene@olchc.ie) (Z. Greene).

that a 3-day decrease in hospital stay for this population could save more than 2 billion dollars annually (Lessen, 2011). This fact alone makes it tempting for many financially stretched health care providers to look at the implementation of interventions in this population that will facilitate early oral feeding. Early exclusive oral feeding has thus become an important focus of intervention for the multidisciplinary team.

Oral stimulation interventions are popular and many are described in the literature, all developed to promote early oral feeding (See Table 1). Pinelli and Symington (2005) report that non nutritive sucking (NNS) was found to decrease significantly the length of hospital stay for preterm infants and had a positive influence on transition from tube to bottle feeds with better bottle feeding performance. Another systematic review has explored direct oral stimulation techniques (Arvedson et al., 2010). This concluded that although oral motor interventions show promise for enhancing feeding and swallowing in preterm infants, there remains no clear direction for clinical practice.

Our team has set out to address specific key questions regarding oral interventions with preterm infants and to provide some evidence for both clinical practice and research in the area. A protocol for this review is published (Greene et al., 2012) and a Cochrane systematic review is underway. In conducting this review we have encountered two key challenges:

1. the construction of a theoretical framework to support the practice of oral motor interventions.
2. negotiating the published literature due to variations in terminology used and lack of clear protocols for practice internationally.

## Oral interventions for preterm infants: the theoretical framework for practice

### The development of oral feeding in the preterm infant

Oral feeding is a complex skill requiring the integration of breathing, sucking and swallowing in the context of overall motor stability and incoming sensory stimuli (Arvedson et al., 2010; da Costa et al., 2010a). It depends upon brainstem central pattern generators whose activity is increasingly influenced by chemosensory and oral tactile input (Amaizu et al., 2008; Bingham, 2009). For the preterm infant the transition to oral feeding from gavage (tube) feeding can be a challenge as it requires ability to coordinate the muscles of the jaw, lips, tongue, palate and pharynx, upper trunk and respiratory systems in order to support a safe swallow. It is also dependent on normal sensory functioning, for example the presence of reflexes of rooting, gagging, swallowing, as well as intra-oral and pharyngeal sensation. Therefore, both sensory and motor systems must reach a critical stage of development for the infant to be able to feed orally.

The developmental stages of sucking in low birth weight preterm infants during bottle feeding have been described (Amaizu et al., 2008; Bingham et al., 2010; Dodrill et al., 2008a; Neiva and Leone, 2007). Varying components of sucking physiology such as sucking amplitude, rate, pressure intensity, timing of sucking cycles, sucking proficiency and efficiency appear to mature over time although at varying rates depending on several motor and sensory factors (Bingham et al., 2010; Poore et al., 2008; Matsubara et al., 2005). Preterm infants frequently remain in hospital for protracted periods as they learn to transition from gavage to oral feeds, mastering these skills.

**Table 1** Oral stimulation interventions.

Named intervention	Clinical trials
Perioral stimulation ranging from 5 to 15 min	Boiron et al. 2009/2007; Harding et al., 2006; Gaebler and Hanzlik, 1996; Neiva and Leone, 2006/2007; Lessen, 2011
Patterned orocutaneous therapy – ‘pulsating pacifier’	Poore et al., 2008/Barlow et al., 2008
Perioral stimulation followed immediately by pacifier for NNS	Fucile et al., 2012/2011/2005/2002; Pimenta, 2008; Rocha et al., 2007
Pacifiers during gavage feeds	Yildiz and Arikan, 2011/Field et al., 1982;
Sweet pacifier	Mattes et al., 1996
Semi-demand gavage feeds & pacifier during feeds	McCain et al., 2001/McCain and Gartside, 2002
Music therapy – pacifier activated lullaby	Standley et al., 2010/Yildiz et al., 2011
Oral support during feeding	(Boiron et al., 2009)
Tactile/kinesthetic whole body stimulation	(Fucile et al., 2011/2012; Bragelien et al., 2007)

However, the development of feeding in the preterm infant can be complicated by the presence of a multiplicity of other factors, which must be taken into consideration for holistic management.

### Factors influencing the development of oral feeding in the preterm infant

In the preterm population, the existence of several comorbidities e.g. respiratory disease, can impose limits on the opportunities for sucking. This can deprive the infant of necessary oral sensori-motor experiences during a critical period of brain development when central patterning of suck and feeding skills are being refined (da Costa et al., 2010b; Mizuno et al., 2007; Stumm et al., 2008). Other medical interventions used in preterm infants (e.g. prolonged intubation, continuous positive airway pressure, nasal cannulation, regular oropharyngeal, nasal or tracheal suction) may compound negative responses by the infant to oral feeding trials (Bingham, 2009; Dougherty and Luther, 2008; Jadcherla et al., 2010). General factors such as prefeeding behavior, state and feeding experience also influence feeding performance in this population (Dodrill et al., 2008a; Pickler et al., 2006). Some intervention that would ameliorate the impact of negative feeding experiences, provide some positive oral motor sensory stimulation and expedite the transition from tube to oral feeding would therefore seem important.

### Factors influencing the selection of an oral intervention

Readiness to feed is an important construct in the argument for oral motor interventions. Empirically derived guidelines for either starting or progressing oral feeds are lacking (Crowe et al., 2012; Pickler et al., 2006). The criteria for making judgments on readiness to feed can vary between centers and seems dependent on a range of factors such as age, weight, oral motor skills, feeding techniques, and feeding experience (Crowe et al., 2012; Dodrill et al., 2008b; Zimmerman and Barlow, 2009). Using age alone as a deciding factor for feeding is a crude measure as it does not consider other feeding readiness indices such as respiratory state, physiologic stability, self regulation skills etc. To help clinicians determine readiness for feeding and suitability for oral trials, a number of authors have provided some direction. For example, the Early Feeding Skills Assessment for preterm infants (Thoyre et al., 2005) and the more recent SOFFI – Supporting Oral Feeding in

Fragile Infants (Ross and Philbin, 2011a,b) provide some direction for evaluation. Other studies incorporate observation of infant behavior before feeding (Als et al., 2003). Cue based and semi demand feeding protocols have been described which rely on observations of the infant behavior, requiring clinicians to seek cues indicating feeding readiness instead of administering gavage feeds on a strict four hourly basis (McCain and Gartside, 2002). A Cochrane review in this area revealed limited evidence that this approach allows earlier attainment of oral feeds and earlier hospital discharge (McCormick et al., 2010).

Having determined the readiness to feed, the next challenge is to determine which specific intervention can facilitate sucking and feeding development to expedite the transition to oral feeding. The clinician is faced with a range of approaches (See Table 1). In broad terms these interventions are designed to decrease oral hypersensitivity, improve range of motion and strength of muscles for sucking (Fucile et al., 2002), increase oral motor organization (Case-Smith, 1989) and activate reflex behaviors that facilitate nutritive sucking (Leonard et al., 1980). In general the techniques aim to normalize sensation by restoring reflexes and in turn elicit normal oral movements of lips, tongue, jaw and pharynx for sucking and swallowing development. The decision on which approach is most effective lies in deciphering the evidence.

### Challenges in reviewing the evidence for oral motor interventions

#### Terminology: Who is the study about?

Preterm infants are typically defined as those born before 37 weeks postmenstrual age (PMA) i.e. up to 36 weeks and 6 days. The definition of preterm can vary (see Table 2). When definitions are used, they can lead to further confusion as a variety of terms are used to describe populations in studies on preterm infants (Table 2). The American Academy of Pediatrics (2004) recognized this problem over a decade ago with a call for consistency in the use of definitions to describe the length of gestation and age in neonates. Many studies fail to differentiate between early (EPT) and late (LPT) preterm infants and again there is confusion on these definitions. Some studies define LPT as 34–36 weeks gestational age with EPT preterm infants classified those <34 weeks gestational age while others (Gunville et al., 2010)

**Table 2** Age terminology used to describe preterm infants.

Term	Definition
Gestational age/menstrual age	Time elapsed between the first day of the last normal menstrual period and the day of delivery
Chronological age/postnatal age	Time since birth
Postmenstrual age (PMA) <sup>a</sup>	Time between the first day of the last menstrual period and birth (gestational age) plus the time elapsed after birth (chronological age).
Conceptual age (should be avoided) <sup>a</sup>	Time elapsed between the day of conception and the day of delivery
Corrected age (use after perinatal period) <sup>a</sup>	Chronological age reduced by the number of weeks born before 40 weeks of gestation.

<sup>a</sup> Recommended by American Academy of Pediatrics, 2004.

define EPT as <32 weeks' gestational age and LPT as >32 weeks' gestation age at birth.

The implications are that it is often impossible to make an informed judgment on the efficacy and effectiveness of interventions used for the populations described or make comparisons to similar populations.

### Interventions: what is the intervention?

The intervention itself is not always clearly defined in the research literature. For the purposes of our Cochrane review we define oral stimulation as: 'the sensory stimulation to or manipulated actions of the lips, jaw, tongue, soft palate, pharynx, larynx, and respiratory muscles before or during either nutritive sucking (NS) or nonnutritive (NNS) events, intended to influence the oropharyngeal and respiratory sensorimotor mechanisms in order to improve function for sucking and feeding in preterm infants' (Greene et al., 2012 p. 2). We determined that stimulation of NNS could be considered an oral stimulation intervention and that specific oral stimulation interventions could include activities to develop both NNS which involves use of a pacifier before or during tube or bottle feeds and/or direct oral or peri-oral stimulation techniques to facilitate eventual NS.

However, studies are not always clear about what exactly the intervention involved, who provided the intervention, the intensity of the intervention, and the context in which it was delivered (Table 1). Several authors describe more than one

intervention (e.g. perioral stimulation program followed by a period of nonnutritive sucking on pacifier) but fail to determine which aspects of this intervention 'package' could be contributing to the eventual outcomes.

There are many other factors that augment the intervention provided making it difficult to discern if it is the intervention itself or the context in which the intervention is delivered that is important. Environmental and physical modifications such as eliminating external stimuli (e.g. light, noise, other sensory experiences) during feedings, using therapeutic nipples on bottles to manipulate milk flow rate, positioning and swaddling of the infant to support the motor and sensory system and promote flexion are all believed to prepare the infant for the feeding situation (Ross and Philbin, 2011a,b). Simple facts like holding the infant during feeding versus infant positioned supine in the incubator are important as they create two separate feeding environments for the infant, which may modulate feeding behavior. These modifications ensure that infants are suitably calm, alert and ready to attempt oral feeding. Direct replication of the intervention can be difficult with variations in research and clinical practice evident from the studies.

Indeed there are a selection of studies testing a range of other interventions which appear to have a positive impact on feeding skill and efficiency by using methods such as cross cut nipple teats (Chang et al., 2007), a controlled flow vacuum bottle system (Fucile et al., 2009), spoon feeding (Kumar et al., 2010), Auditory, Tactile, Visual and Vestibular (ATVV) interventions (White-Traut et al., 2002), breast milk odor (Yildiz et al., 2011) or music therapy (Vianna et al., 2011). Do these interventions come under the umbrella of oral stimulation intervention as they share similar outcomes? Perhaps our overriding definition of 'Oral stimulation intervention' needs to be more carefully defined to reflect the continuum of practices reported.

### Outcome of interventions: What to measure?

The outcome measures for the interventions in the published literature vary. Our review is concerned specifically with outcome measures that signify improvement in oral feeding ability and oromotor function of the preterm infant and that reduce NICU and/or overall hospital stay. Suggestions for outcome measures in this population are provided in Table 3. Potential adverse outcomes associated with oral stimulation interventions also need to be documented with careful monitoring of events

**Table 3** Suggested outcome measures for oral interventions.

Primary outcomes	Measurement
Time taken to achieve exclusive oral feeding	Number of days from commencement of intervention to first day of exclusive oral feeding
Time taken to transition from tube to full oral feeds	Number of days from commencement of intervention to first day of exclusive oral feeding
Total hospital stay	Number of days of total hospital admission including days in hospital post NICU discharge
Duration of parenteral nutrition	Number of days on parenteral nutrition
Maturation in sucking strength	Measured by e.g. rate of milk intake (ml/min); suction amplitude (mmHg/sucks per minute); objective measures arising from digital equipment/suck transducers assessing suck ability
Secondary outcomes	Measurement
Exclusive oral feeding at term corrected age,	Taking eight feedings per day for 2 consecutive days (Fucile et al., 2002) or able to take more than 80% of the prescribed total fluid intake orally in a 24 h period (Premji et al., 2004)
Exclusive direct breastfeeding at term corrected age,	Full oral intake delivered by breast feeding and measured qualitatively using a breast feeding assessment tool e.g. LATCH breastfeeding charting system
Any direct breastfeeding at term corrected age,	At least one feed delivered via breast in 24 h time period
Growth measures	Weight gain (g/kg/day), Length of body (cm/day), Headcircumference (cm/day)
Developmental outcomes	Ascertained by a validated instrument at 12–18 months
Family satisfaction with intervention,	Satisfaction questionnaire/survey
Non-compliance with intervention.	Observation, caregiver report

such as sepsis, oral infection, oral trauma, apnea or bradycardia episodes that require intervention from the caregiver (e.g. stimulation, oronasal suction, increase in delivery of oxygen, assisted ventilation) or increase in salivary flow (as measured by the presence of saliva beyond the level of the lips), oxygen dependence at 36 weeks PMA, or death during initial hospital stay.

### Follow up periods after intervention

More longitudinal studies are required to determine the efficacy of an intervention. Many studies fail to consider outcomes beyond hospital discharge. Gunville et al. (2010) found that children born preterm comprise a substantial proportion of admissions to the Pediatric Intensive Care Unit (PICU) for respiratory illness in the first years of life. As a result, they utilize considerably more hospital resources and incur more expense than full term infants. Since feeding and swallowing difficulties can be strongly associated with respiratory difficulties, longer-term outcomes for oral interventions should include respiratory outcomes

as well as feeding behaviors, weaning difficulties, and feeding aversions (Samara et al., 2010).

### Discussion

Undoubtedly the argument for oral interventions to improve feeding in preterm infants will remain debated for some time to come. We believe that without more robust well-designed research in the area, as multidisciplinary team members, we may well be misdirecting our efforts in with this population. More multi-center RCTs are required that conform to CONSORT guidelines of reporting (Schulz et al., 2010). Clear descriptions of populations selected with precise definitions of the characteristics of the population, accurate recording of the infant's readiness to feed, detailed description of the intervention itself, its method (frequency, intensity and duration) and context of delivery with valid and reliable outcome measures recorded are required. We suggest both primary and secondary outcomes with long term follow up of infants' feeding behaviors post follow discharge. We propose that a range

of time frames be reported, for example, immediate change, medium term change (6–12 months) and/or long-term change (12 months +).

Small intervention studies that are well designed and accurately reported will lend themselves more readily to meta-analysis. Only with this evidence, will we then be able to deliver comprehensive cost effective services to this population.

## Conflict of interest statement

Authors have no conflicts of interest to declare.

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