JSLHR

Technical Report

Modified-Bolus Placement as a Therapeutic Tool in the Treatment of Pediatric Feeding Disorders: Analysis From a Retrospective Chart Review

Valerie M. Volkert,[a,b] William G. Sharp,[a,b] Michele Cole Clark,[b,c] Hailey Ormand,[b,d] Emily Kate Rubio,[b,e] Courtney McCracken,[a] and Leah Bryan[a]

Purpose: Recognizing the need to advance the treatment of pediatric feeding disorders, an emerging area of inquiry focuses on therapeutic techniques that address expulsion and packing possibly associated with oral–motor dysfunction. In the current study, we documented the use of modified-bolus placement in the treatment of pediatric feeding disorders at an intensive, multidisciplinary day-treatment center over a 26-month period.
Method: The retrospective observational cohort study involved patients admitted for the assessment and treatment of chronic food refusal from August 2013 to October 2015.
Results: Patients (n = 23) who received modified bolus placement displayed moderate-to-severe oral–motor deficits. Use of modified-bolus placement was associated with reduced expulsion and packing of bites during meals, and treatment gains coincided with a threefold increase in grams consumed per meal.
Conclusion: Results provide additional support for the potential therapeutic benefits of enhancing bolus placement onto the tongue as a means to improve mealtime performance in children with pediatric feeding disorders when included as an adjunct to more traditional behavioral approaches.

Eating is a complex process involving the intricately timed and sequential coordination of the lips, tongue, cheeks, and jaw to promote safe consumption and assure appropriate growth (Delaney & Arvedson, 2008). For most children, the skills and behaviors associated with eating unfold seamlessly as part of a process typically viewed as instinctual and related to survival (Kerwin, 1999; Volkert & Piazza, 2012). This process, however, can be disrupted by medical and/or developmental conditions, which hinder advancement of age-typical eating and place a child at risk for developing a pediatric feeding disorder. Between 40% and 70% of children with complex medical histories experience feeding difficulties (Lukens & Silverman, 2014). These medical conditions are often associated with unpleasant consequences (i.e., pain, nausea, and/or fatigue), which are repeatedly paired with eating, and this promotes conditioned food aversion (Hyman, 1994). Children who develop a feeding disorder learn to avoid contact with food by engaging in disruptive mealtime behaviors, such as crying, tantrums, and/or pushing the food away (Piazza et al., 2003), and are at increased risk for developing experience-based oral–motor concerns due to lack of exposure to the typical oral experiences associated with eating.

In the extant literature, considerable evidence supports the role of learning in maintaining food refusal among children with feeding disorders (Piazza et al., 2003; Volkert, Patel, & Peterson, 2016). In general, this line of research emphasizes the contribution of negative reinforcement (i.e., escape from mealtime demands) in shaping refusal behaviors during meals. A common mealtime dynamic involves a caregiver understandably removing food and/or ending meals when faced with persistent food refusal (Sharp, Volkert, Scahill, McCracken, & McElhanon, 2017). As a result, the

[a]Department of Pediatrics, Emory University School of Medicine, Atlanta, GA
[b]Pediatric Feeding Disorders Program, Marcus Autism Center, Atlanta, GA
[c]Children's Healthcare of Atlanta, Inc., GA
[d]Behavioral Psychology Department, Kennedy Krieger Institute, Baltimore, MD
[e]Department of Counseling and Psychological Services, Georgia State University, Atlanta
Correspondence to Valerie M. Volkert: vvolker@emory.edu

Editor-in-Chief: Julie Liss
Editor: Michelle Ciucci
Received June 29, 2018
Revision received December 20, 2018
Accepted January 8, 2019
https://doi.org/10.1044/2019_JSLHR-S-18-0268

Disclosure: The authors have declared that no competing interests existed at the time of publication.

child learns to avoid food by engaging in disruptive behaviors, which may persist and strengthen overtime if this pattern of parent–child interaction continues. If disruptive behaviors do not produce the desired outcome (i.e., food removal), the child may exhibit an increasingly wide range of alternative topographies to avoid eating, including expulsion (spitting the food out), packing (holding food in the mouth for extended periods), gagging, and/or vomiting (Sharp, Odom, & Jaquess, 2012; Vaz, Piazza, Stewart, Volkert, & Groff, 2012). While a fairly robust evidence base analyzing the function and/or treatment of these maladaptive behaviors in children with pediatric feeding disorders exists (Sharp, Jaquess, Morton, & Herzinger, 2010), considerably less research has examined the possible role of oral–motor/oral–sensory dysfunction in the development and maintenance of food refusal. This gap in the literature is unfortunate, given that oral–motor skill deficits hold potential to both contribute to and maintain feeding problems (Field, Garland, & Williams, 2003).

Field et al. (2003) conducted the first large-scale evaluations focusing on the prevalence of oral–motor skill concerns (which the authors defined as problems with chewing, tongue movement, and lip closure) among children with pediatric feeding disorders. The study included 349 children (ages 1 month to 12 years) referred to a multidisciplinary program for evaluation of chronic feeding issues. Oral–motor delays were the most prominent feeding concern documented in this study, occurring in 44% of the sample (155 participants). More recently, Crapnell et al. (2013) conducted a longitudinal study investigating the early medical and family factors associated with later feeding difficulties in 80 preterm infants (≤ 30 weeks gestation). Eighteen children (23% of the sample) displayed feeding problems at the age of 2 years, with greater risk associated with hypotonia during infancy. The authors posited that hypotonia may impair development of the motor skills required to transition through the stages of feeding development, thus making management of solid food more challenging. This assertion is consistent with research identifying certain pediatric subgroups at increased risk for both feeding difficulties and oral–motor dysfunction, such as impaired muscle tone associated with Down syndrome, congenital hypotonia, or neurological conditions such as cerebral palsy (Sharp, Berry, Cole-Clark, Criado, & McElhanon, 2016). These findings highlight the importance of feeding intervention to include therapeutic support to improve oral–motor skills—in addition to behavioral, nutrition, and volume goals—to optimize feeding outcomes among children with complex feeding disorders (Sharp et al., 2017).

Intensive multidisciplinary intervention at day-treatment programs and inpatient settings is increasingly recognized as the standard of care for children with complex feeding disorders (Lukens & Silverman, 2014; Sharp et al., 2017). Disciplines involved in providing care most often include psychology, medicine, nutrition, occupational therapy, and speech-language pathology. This team approach provides the clinical oversight to address the behavioral, medical, dietary, and skill-based concerns (respectively) ubiquitous to feeding disorders. It also permits monitoring for potential complications (e.g., aspiration, allergic reactions) when introducing food to children with limited or no experience eating. Behavioral intervention—which includes positive reinforcement of appropriate mealtime behaviors, bite persistence (a.k.a., contingency contacting, escape extinction), and/or stimulus fading—represents the most frequently researched and well-supported treatment occurring at multidisciplinary programs (Sharp et al., 2017). Research supporting behavioral intervention primarily focuses on treatment packages that address the operant function of food refusal (i.e., escape from mealtime demands) while concurrently seeking to ameliorate possible side effects (e.g., crying, disruptions) associated with the introduction of food (Sharp, Jaquess, et al., 2010).

Recognizing the need to advance the treatment of pediatric feeding disorders, an emerging area of inquiry focuses on therapeutic techniques that address mealtime difficulties—such as expulsion and packing—possibly associated with oral–motor dysfunction. Specifically, a series of case studies indicate altered bolus placement onto the tongue may lead to improvements in bolus retention and/or oral phase to swallow when included as an adjunct to behavioral approaches (e.g., bite persistence, reinforcement) during intensive multidisciplinary intervention (Girolami, Boscoe, & Roscoe, 2007; Sharp, Harker, & Jaquess, 2010; Sharp et al., 2012; Stubbs, Volkert, Rubio, & Ottinger, 2018; Wilkins et al., 2014). In these studies, methods for modifying bolus placement include flipped-spoon presentations or the use of a Nuk brush (i.e., marketed as an infant gum massager with soft, chewable bristles) to deposit the food directly onto the tongue for children with oral–motor deficits.

Collectively, results supporting altered bolus presentations suggest that, while packing and expulsion may be the product of learning in some cases, a subgroup of children with feeding disorders may also lack the oral phase skills required to collect the food particles and effectively propel the bolus posteriorly to swallow. Specifically, modified-bolus placement (i.e., depositing the food directly onto the child's tongue at midline) has been posited in prior case studies to compensate for poor oral–motor skills—likely by assisting with bolus awareness, collection, and posterior transit and thus decreasing the effort and coordination needed to propel the bolus posteriorly. Although the therapeutic benefits of modified-bolus placement appear promising, there are several limitations to the extant literature. Notably, support is derived solely from case studies involving fewer than a dozen total participants. In addition, although it has been hypothesized that the therapeutic benefits of alternative bolus placement may be associated with patients with oral–motor deficits, past reports omit a formal evaluation of oral–motor function to characterize patients who would most benefit from these procedures. Finally, there has yet to be a programwide analysis regarding the utilization of modified-bolus placement at programs specializing in intensive multidisciplinary intervention. Such an analysis would provide greater clarity regarding the mealtime difficulties most commonly targeted with these procedures.

With these limitations in mind, the current study sought to explore the choice of modified-bolus placement by clinicians treating patients admitted to an intensive day-treatment program over a 26-month period. The goals of this program-wide analysis were to (a) assess patient characteristics associated with the use of modified-bolus placement as an adjunct to behavioral intervention, including profiling the oral–motor functioning and mealtime difficulties associated with the use of these procedures; (b) document the therapeutic trajectory associated with these procedures; and (c) determine the clinical outcomes of patients in terms of the continued use or removal of this therapeutic support prior to discharge.

Materials and Methods

Study Design and Patient Selection

This study involved a cross-sectional electronic medical record (EMR) review of patients referred to a day-treatment program specializing in the assessment and treatment of pediatric feeding disorders. Disciplines involved in overseeing assessment and treatment included licensed psychologists, dieticians, a speech-language pathologist (SLP), an occupational therapist (OT), a social worker, a nurse practitioner, and a pediatric gastroenterologist. General admission requirements included (a) meeting diagnostic criteria for avoidant/restrictive food intake disorder (ARFID)—the broader psychiatric diagnosis for feeding disorders (Sharp et al. 2017)—as evidenced by dependence on enteral feeding, oral nutritional formula supplementation, significant nutritional deficiency, and/or growth failure; (b) confirmed history of active and persistent mealtime behavioral difficulties (e.g., crying, tantrums); and (c) minimal prerequisite oral–motor skills required to support oral intake as determined by a nonnutritive mechanical oral–motor evaluation conducted by an SLP or OT. To select patients for inclusion in this review, we employed a two-step process. First, we identified all children between 8 months and 17 years of age admitted to the program between August 2013 and October 2015 for treatment of food refusal. The clinic definition of food refusal required dependence on formula either by enteral or oral formula supplementation (e.g., by bottle) for 50% or more of a child's caloric needs or failure to consume adequate intake to promote growth (i.e., faltering growth). Food refusal, by this definition, could also involve a limited variety of food consumed during meals; however, food refusal superseded our clinic definition of severe food selectivity (i.e., complete rejection of one or more food groups—fruits, vegetables, proteins, grains, dairy; accepting five or fewer total food items) if both were present. The multidisciplinary team identified and recorded the primary presenting complaint in the EMR at the time of the initial evaluation (described below).

Patients were excluded if they had a feeding concern exclusively associated with limited variety (severe food selectivity but adequate caloric intake) by review of the chief complaint in the EMR at the time of admission. Next, we identified the subset of patients whose treatment involved modified-bolus placement (i.e., flipped-spoon procedure or Nuk-brush presentation) for five or more consecutive meals during admission. Two authors (V. V. and W. S.) independently searched all patient charts, reviewed and screened potential patients, and reached consensus on final inclusion (see Figure 1). This study was approved by the institutional review board of the Emory University School of Medicine.

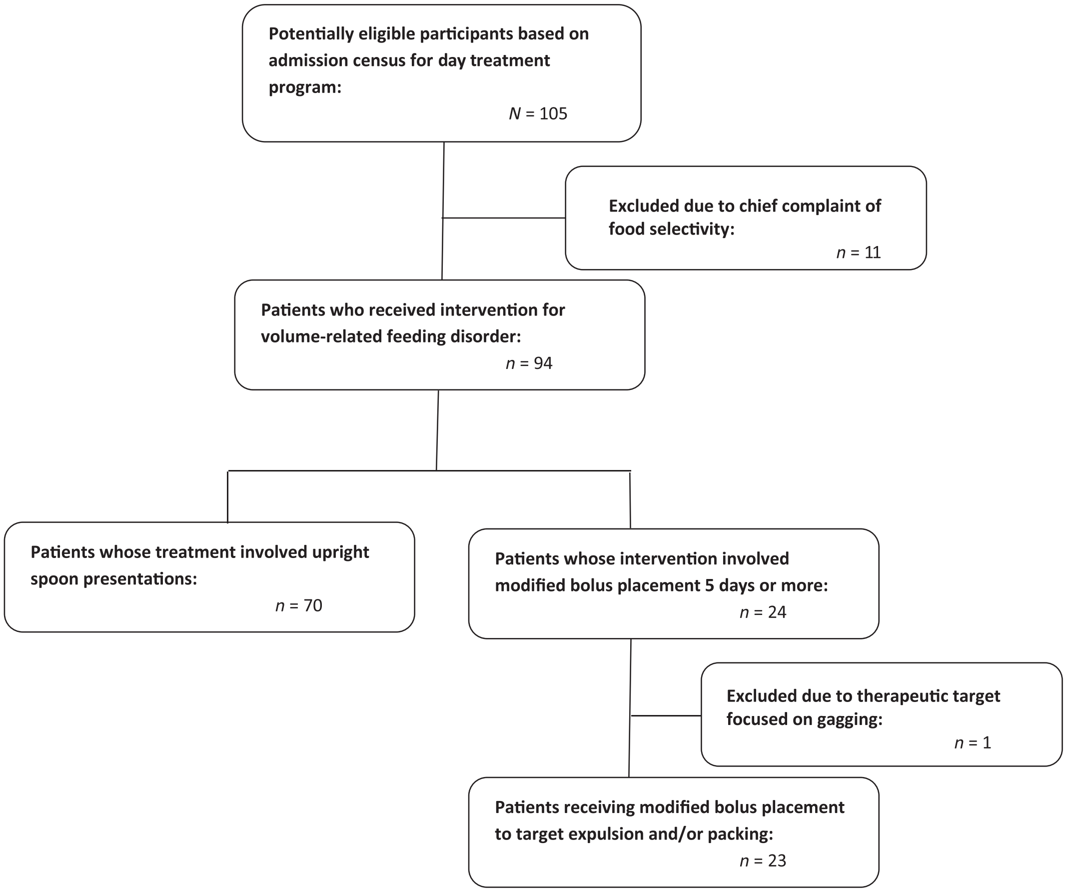
Treatment Setting and Approach

Patients admitted to the day-treatment program received four therapeutic meals per day from a team of feeding therapists working under the supervision of the multidisciplinary team. All meals occurred in a private treatment room with an adjacent observation room. Patients sat in age-appropriate or developmentally appropriate seating (e.g., highchair, booster seat), and treatment rooms contained a table, feeding utensils (e.g., maroon spoons, Nuk brush, rubber-coated baby spoon), bib, serving tray, and a scale with an intake log. For all patients, four therapeutic meals occurred per day on a regular schedule (e.g., 9:30 a.m., 11:00 a.m., 12:30 p.m., 3:15 p.m.) throughout the week (Monday to Friday, 20 therapeutic meals per week). Meal spacing aimed to provide adequate time for digestion to occur, with long breaks between lunch and dinner to permit napping. A registered dietitian managed and/or adjusted a patient's feeding schedule with enteral or oral formula supplementation based on a child's response to intervention (i.e., to account for increased oral intake) during nonclinic hours.

Treatment targeted a total of 16 food items (four fruits, four vegetables, four grains, and four proteins). For each patient, a dietitian developed the menu of target foods with low probability for food allergies or cultural/parental dietary restrictions. For each meal, a feeding therapist randomly selected one food item from each group and presented these four foods (in random order) at a designated texture (e.g., puree) and bite volume (e.g., approximately 1 cc per bite). In most cases, our model of care involves initiating intervention with a pureed texture to promote taste exposure and reduce the overall feeding demand (i.e., no chewing) among children with longstanding food refusal. Treatment involved pureed texture for all patients who received modified-bolus placement due to skill and safety concerns.

Intervention followed a sequencing of techniques developed through our clinical practice and a review of extant literature. A manual-based version of this approach is described and evaluated in one of the few randomized controlled trials in the field (Sharp, Stubbs, et al., 2016). Treatment meals involved formal protocols that specified feeder behavior (e.g., verbal instructions, prompts, and social attention), format of bite presentations (volume and variety of food presented), bite spacing (approximately every 30 s), level of persistence with mealtime demands, and consequences for appropriate and inappropriate mealtime behaviors (e.g., access to a toy or other preferred item and removal of

Figure 1. Flow diagram for patient selection.



feeder attention, respectively). Feeding therapists, individuals with a minimum of a bachelor's degree in the social sciences who received in-house training using instruction, modeling, and rehearsal, with immediate and then postsession feedback to our benchmark competency (implementing all treatment components with at least 80% accuracy for three consecutive meals), implemented the meal protocols. In all cases, modified-bolus placement was incorporated into our standard model of behavioral intervention that includes antecedent manipulations (e.g., stimulus fading of bolus size), persistence of bite presentation (i.e., nonremoval of the spoon), reinforcement procedures, and formalized meal structure (i.e., scripted instructions, bite presentation cadence). Different treatment elements, including modified-bolus placement, were introduced sequentially into intervention based on a child's pattern of performance during the course of the admission. In cases involving persistent packing and/or expulsion, our treatment model involves, first, introducing treatment elements that attempt to increase motivation to retain and swallow food (e.g., differential reinforcement for mouth clean) and/or reduce the feeding demand (e.g., antecedent reduction in the bite volume). Introduction of modified-bolus placement occurred in cases where packing and/or expulsion persisted at moderate to high levels (e.g., occurring 40% or more across multiple meals) despite the use of these behavioral strategies.

Therapeutic Bolus-Placement Methods

Bolus-placement methods included (a) upright-spoon presentation, (b) flipped-spoon presentation, and (c) Nuk-brush presentation. Upright-spoon presentation—the default therapeutic approach in the clinic—involved the feeder inserting the bowl of spoon into the mouth and removing the spoon after the patient closed the lips around the spoon or, if the patient had an open mouth posture, by gently scraping the food onto the back of the front teeth or top lip. Flipped-spoon presentation involved five steps: (a) inserting the bowl of an upright spoon into the mouth, (b) positioning the bowl halfway between the anterior and posterior tongue, (c) using the bowl of the spoon to flatten the tongue using gentle downward pressure (as needed), (d) rotating the spoon 180° (i.e., flipping), and (e) depositing the food on the tongue using gentle downward pressure along with a concurrent wiping motion while dragging the spoon toward the lips and out of the mouth (Sharp, Harker, et al., 2010; Sharp et al., 2012). Nuk presentation involved three steps: (a) inserting the Nuk with the bolus positioned on the top of the utensil, (b) positioning the Nuk halfway between the anterior and posterior tongue or midblade, and (c) gently rolling the brush 180° to deposit the bolus (Girolami et al., 2007; Wilkins et al., 2014). Regardless of the patient's age, modified-bolus placement (flipped spoon or Nuk) always involved a feeder holding the utensil and depositing the bite (i.e., non-self-feeding). The multidisciplinary team selected the placement method employed during intervention based on (a) a systematic evaluation of a patient's response to the different placement methods (see Sharp et al., 2012, for further description); (b) observed oral–motor status/patterns during therapeutic meals, and/or (c) logical considerations regarding the use of a procedure with a particular patient (e.g., size of the child's mouth, possible volume of food on the utensil, behavioral response to the procedure).

Data Collection and Extraction

Data collection on study measures occurred (a) as part of a patient's pre-admission multidisciplinary evaluation (approximately 3 hr) involving psychology, medicine, nutrition, and speech-language pathology or occupational therapy to determine appropriateness for day treatment and (b) during daily therapeutic meals as part of a patient's admission to the day-treatment program (approximately forty days typical length of stay). During the pre-admission evaluation, the multidisciplinary team employed an EMR template for each discipline that summarizes data obtained on the medical, behavioral, oral–motor, and nutritional concerns often present among patients with pediatric feeding disorders (Sharp et al., 2017). The assessment included measurement of growth parameters, nutritional analysis based on a 3-day food record, oral–pharyngeal motility study (a.k.a. modified barium study) review (if applicable), meal observation, and global developmental and behavioral screening. During day treatment, a feeding therapist collected data on mealtime performance using a bite-by-bite data collection system tracking operationally defined variables (described below), capturing data during all bites across all meals (see Sharp, Jaquess, Morton, & Miles, 2011 for more details on clinical setting and approach), which is summarized in the EMR.

A systematic procedure with corresponding protocol and spreadsheet guided data extraction from the EMR for study measures among eligible subjects. Two investigators (V. V. and W. S.) conducted data extraction independently. The double-entered data allowed for the calculation of percent agreement. Coder agreement was 93.3% (range: 73.5%–100%), exceeding the 80% acceptable standard of agreement recommended during quantitative synthesis of research (Campbell, 2003). To further ensure the accuracy, we reached consensus on all areas of discrepancy highlighted during the interrater analysis on all extracted data. Discrepancy review involved the coders meeting to revisit each patient's EMR involving disagreement, discussing their coding approach, and reaching agreement regarding the data to be included in the current review. In such cases, the agreed-upon data, however, did not change coder agreement scores.

Extracted Measures

Patient Demographics

Patient demographic variables included age, gender, primary feeding concern (e.g., tube dependence, poor oral intake), bolus-placement method, medical conditions (e.g., prematurity, food allergies, constipation), length of admission, mealtime difficulty targeted (i.e., packing and/or expulsion), and when in treatment bolus-placement method introduced by session number.

Oral–Motor Skill

During the multidisciplinary evaluation, an SLP or OT performed a structured clinical oral–motor/oral–sensory assessment that included (a) minimum completion of the Beckman Oral Motor Evaluation (BOME; Beckman, 1986/2013; a criterion-referenced formal oral–motor tool used to establish baseline minimal mechanical anatomic competencies of motor function of the tongue, lips, cheeks, jaw, and hard and soft palate; the use of the tool provides salient information about the current minimal competencies for mechanical movements that are anatomically based, not dependent on state or cognition; however, BOME results are not predictive of swallow efficiency nor predicative of swallow safety—the evaluation process provides information that permits an evaluator to identify whether an individual may have impaired response and/or reduced strength, range of movement and lingual variety of movement that impact success during nutritive trials); (b) a detailed clinical interview focusing on the collection of background information concerning early feeding experiences (e.g., response to the introduction of solid foods, difficulty with milestone transitions with food types or textures), current feeding practices (e.g., seating arrangements, utensils, support provided by caregivers), and repertoire of food textures (e.g., pureed, table foods); (c) mealtime observation of a typical meal providing information regarding efficiency within the meal (i.e., mastication, lingual bolus control, effort of mastication, timeliness of the oral phase preparation of the bolus prior to the swallow, and coordination) of each of these components during consumption of preferred foods; and (d) the Beckman Oral Hypersensitivity Scale (Beckman, 2004). The SLP and OT completing clinical and mealtime assessments were certified in the BOME and Intervention Protocol. These combined quantitative evaluation components were used to determine each child's level of nutritive and nonnutritive mechanical oral–motor functioning using a 4-point rating scale (ranging from within functional limits to severe), with higher scores reflecting more pronounced oral–motor dysfunction using the criteria outlined in Table 1 (Beckman, 1986/2013, 2004).

Mealtime Performance Variables

As standard clinical practice, the feeding therapist recorded bite-by-bite data on mealtime performance during

Table 1. Oral–motor rating system.

Rating score	Description of performance
Within functional limits 1	Corresponds to mechanical oral–motor skill in the area of strength and range of movement of the tongue, jaw, and cheeks, falling in the category of "most consistent function patterns" (above 80%) on the Beckman Oral Motor Evaluation and mild to within normal limits for oral hypersensitivity on the Beckman Oral Hypersensitivity Scale. This rating is also supported by the child's ability to eat a number of age-appropriate foods, that is, chewable solids of mixed textures with oral transit and swallow as expected for age.
Mild 2	Corresponds to general mechanical oral–motor skill in the area of strength and range of movement of the tongue, jaw, and cheeks, falling in the category of "emerging/inconsistent oral–motor patterns" (50%–80%) on the Beckman Oral Motor Evaluation and mild to moderate oral hypersensitivity concerns on the Beckman Oral Hypersensitivity Scale. This rating is also supported by a mealtime observation demonstrating lack of age-appropriate foods, such as eating smooth, mashed/ground foods, and dissolvable solids and/or soft chewable solids in the daily diet only.
Moderate 3	Corresponds to general mechanical oral–motor skill in the area of strength and range of movement of the tongue, jaw, and cheeks, falling in the category of "most unproductive patterns" (33%–50%) on the Beckman Oral Motor Evaluation and moderate to severe oral hypersensitivity concerns on the Beckman Oral Hypersensitivity Scale. This rating is representative of low strength of durational chew, poor oral volume by mouth, tube or liquid dependency, and lack of age-appropriate foods in the daily diet.
Severe 4	Corresponds to general mechanical oral–motor skill in the area of strength and range of movement of the tongue, jaw, and cheeks, falling in the category of "most unproductive patterns" (less than 33%) on the Beckman Oral Motor Evaluation and severe to profound oral hypersensitivity concerns on the Beckman Oral Hypersensitivity Scale. This rating is representative of poor jaw strength of durational chew, poor lingual variety of movement, poor volume by mouth, tube or liquid dependency, and lack of age-appropriate foods in the daily diet.

all treatment meals. The key mealtime variables for the current analysis were packing, expulsion, and grams consumed, which were operationalized in the following manner: *packing*—holding food larger than the size of a pea anywhere in the mouth 30 s after the feeder deposited the bite; *expulsion*—food larger than size of a pea visible outside the mouth after the bite entered the child's mouth (included instances when a child actively pushed the food with the tongue; removed the food with their hand; or wiped the bolus on their hand, arm, or clothing, as well as when it passively dripped from the mouth following bite deposit); and *grams consumed*—premeal food minus postmeal food. The feeding therapist visually confirmed packing using a three-step prompting sequence (vocal, model, and physical) to look inside the mouth. If the bolus remained in the mouth at 30 s, the feeding therapist scored the bite as a pack and the feeder continued to check the mouth every 30 s until the mouth was clear before presenting the next bite. The feeding therapist scored an expulsion if it occurred at any point during the bite presentations—including instances that occurred before the first 30-s mouth clean check or following a pack. We converted packing and expulsion into percentages by dividing occurrence of a target behavior divided by the total number of bite presentations multiplied by 100. We recorded grams consumed in an electronic spreadsheet after placing all bowls of food on a serving tray on a scale and recording the weight before and after each meal.

A standard practice in our program involves collecting interobserver agreement during a minimum of 20% of each patient's meal sessions via live observation. We provide standardized training for recording target behaviors using operational definitions (see Sharp, Harker, et al., 2010, for an example). All feeding therapists must train to a benchmark competency (80% agreement with an established therapist for all variables across three consecutive meals) before collecting data independently during a meal. In addition to the feeding therapist who served as the primary data collector, a second, independent observer coded data for 30% and 26% of sessions for packing and expulsion, respectively. As standard practice, we calculate interobserver agreement for packing and expulsion by dividing the smaller number of occurrences by the larger number of occurrences reported within a session and multiplying by 100. The mean agreement for packing and expulsion was 95% (range: 0%–100%) and 94% (range: 0%–100%), respectively.

For the current review, data extraction on mealtime performance variables focused exclusively on patients whose treatment involved modified-bolus placement at three points in treatment: *Time 1*—meal prior to modified-bolus placement; *Time 2*—first meal following modified-bolus placement with a spoon volume equivalent to Time 1; and *Time 3*—the fifth meal following the introduction of modified-bolus placement with a spoon volume equivalent to Time 1. This permitted the analyses to consider the immediate impact of modified-bolus placement when first introduced into treatment (Time 2), as well as the durability of any therapeutic benefit at a more distal point in time (Time 3). During the data extraction process, we identified packing and/or expulsion as a target of modified-bolus placement when present for 40% or greater bites at Time 1. Time 1 involved exclusive use of upright-spoon presentations; Times 2 and 3 involved exclusive use of modified-bolus placement throughout the entire meal. Finally, we coded whether patients were able to return to upright-spoon presentations during the course of their day-treatment admission or during outpatient follow-up.

Statistical Analyses

We calculated descriptive statistics for all variables of interest and included means and standard deviation, medians and interquartile ranges, or counts and percentages, as appropriate. To investigate factors associated with modified-bolus placement, we compared demographic variables between the two groups (no modified-bolus placement vs. modified-bolus placement). Variables compared included age, gender, primary feeding concern, medical conditions, number of comorbid conditions, duration of admission, and oral–motor skill status. Chi-square tests were used to compare categorical variables (gender, primary feeding concern, medical conditions, number of medical conditions, oral–motor skill status), and two-sample *t* tests were used to compare continuous variables (age, duration of admission). To examine changes in expulsion, packing, and grams consumed among patients with modified-bolus placement, we performed a one-way repeated-measures analysis of variance to test whether there was a significant change in feeding behavior over time. Given the skewed nature of these outcomes, data were ranked prior to analysis, and the models were run using the rank-ordered data as opposed to the actual variate values. Medians and interquartile ranges are presented at each of the three time points. Post hoc pairwise comparisons were performed (Time 1 vs. Time 2, Time 1 vs. Time 3, Time 2 vs. Time 3) to determine the differences in outcome at three different time points. Pairwise comparisons were made using a Wilcoxon signed-rank test, and difference in medians are reported. A Tukey–Kramer post hoc multiple comparison procedure was used to control the Type I error rate at the 0.05 level for all post hoc multiple comparisons. SAS v9.4 was used to perform univariate analyses of each potential risk factor to determine the association between the covariate and the outcome of interest. Statistical significance was assessed at the 0.05 level.

Results

Patient Demographics

Of the 105 patients admitted to the multidisciplinary day-treatment program during the 26-month review period, 93 patients (66 boys, 27 girls; aged 4.1 ± 2.6 years) received intervention targeting a volume-related feeding concern (i.e., tube or liquid dependence and/or growth failure; see Figure 1). Twenty-four patients received a treatment protocol involving modified-bolus placement for five or more meals. In one case, modified-bolus placement exclusively targeted gagging (packing and expulsion did not occur at levels required for the current review) in response to food in the mouth when presented on an upright spoon, resulting in a final sample of 23 patients (24.7% of the 93 patients). Chi-square or two-sample *t* tests evaluating patient characteristics (age, gender, primary feeding concern, medical diagnoses, number of comorbid conditions, and length of admission) are shown in Table 2. Results yielded no significant differences with age, gender, presence of a certain medical condition (e.g., prematurity, food allergy), medical complexity (as reflected by the number of medical conditions), or average length of admission between the two groups (those patients who did and those who did not receive modified-bolus placement).

For patients who received a treatment package involving modified-bolus placement, 16 cases (69.6% of the 23) involved a flipped-spoon presentation; seven patients (30.4%) received a Nuk-brush placement method (see Table 3). Persistent expulsion represented the most common mealtime difficulty targeted by modified-bolus placement, displayed by 14 patients (60.9% of the subgroup). Five patients displayed packing (21.7%), and four patients (17.4%) dis played both expulsion and packing. On average, modified-bolus placement was introduced into treatment following 80 five-bite sessions (M = 80.6 sessions, range: 6–247 sessions).

Oral–Motor Skill

Most notably, chi-square tests evaluating oral–motor skill status revealed that patients in the modified-bolus placement subgroup were significantly more likely to present with moderate-to-severe oral–motor deficits ($p < .0003$), with a mean rating of 3.7 on the oral–motor coding system compared with 2.6 for patients whose treatment did not involve flipped-spoon or Nuk presentations.

Mealtime Performance Variables

Change in target feeding behaviors across time is presented in Figure 2 and Table 4. During the meal prior to the introduction of modified-bolus placement (Time 1), the median occurrence of expulsion was 83.3% (n = 19) and the median occurrence of packing was 100% (n = 9). Median grams consumed during the meal equaled 4. During the first meal incorporating modified-bite placement into treatment (Time 2), median occurrence of expulsion dropped to 23.3% and median packing dropped to 11.4%. This reflected a median change in expulsion and packing equal to −39.0% ($p < .0001$) and −65.8% ($p = .011$) between performance on Time 2 and Time 1. Improved performance corresponded with an increase to 13 g consumed in the meal (median change = 9, $p < .0001$). Improvements maintained for all three metrics of mealtime performance five meals following the introduction of modified-bolus placement (Time 3). Median occurrence of expulsion equaled 23.1% and median occurrence of packing equaled 5.0% at Time 3, reflecting a −57.5% ($p < .0001$) and −80.0% ($p = .007$) median change on each variable, respectively. Median grams consumed at Time 3 equaled 17. There was no significant change in mealtime performance between Time 2 and Time 3.

Return to Upright-Spoon Presentation

Of the 23 patients treated with modified-bolus placement during the course of the intensive day-treatment admission or during follow-up appointments, 21 (91.3%) patients successfully transitioned back to upright-spoon feedings exclusively (17 patients before leaving the intensive day-treatment program and four patients during follow-up in our outpatient clinic). The remaining two patients did not return to clinic following discharge; thus, data are unavailable

Table 2. Patient demographic and medical history.

Characteristic	Modified-bolus placement (n = 23)	Upright-spoon presentation (n = 70)	p
Age (in months), $M \pm SD$	45 ± 25.1	51 ± 33.5	.306
Gender, n (%)			.219
Male	14 (60.9)	52 (74.3)	
Female	9 (39.1)	18 (25.7)	
Primary feeding concern, n (%)			
Feeding tube dependence	11 (47.8)	31 (43.1)	.767
Bottle/liquid dependence	12 (52.1)	31 (44.3)	.510
Poor oral intake and faltering growth	0 (0)	8 (11.4)	.089
Medical issues, by history,[a] n (%)			
Gastroesophageal reflux disease	16 (69.6)	45 (62.5)	.560
Food allergy	6 (26.1)	23 (31.9)	.628
Failure to thrive	5 (21.7)	29 (41.4)	.089
Cardio/pulmonary	10 (43.5)	46 (63.9)	.102
Prematurity	10 (43.5)	33 (45.8)	.760
Number of medical conditions, n (%)			.184
< 4	19 (82.6)	21 (29.2)	
≥ 4	4 (17.4)	51 (70.8)	
Average admission duration (in days), $M \pm SD$	37 ± 9.4	34 ± 7.8	.306
Oral–motor status,[b] N (%)			.0003
Within functional limits to mild	0 (0.0)	28 (40)	
Moderate to severe	23 (100)	42 (60)	

[a]Includes current and previous medical concerns. [b]At the time of multidisciplinary evaluation.

regarding their status in returning to an upright spoon. In general, assessment of a patient's readiness to transition back to the upright spoon followed procedures described by Sharp et al. (2012).

Discussion

To our knowledge, this is the first program-wide analysis focusing on the use of modified-bolus placement in the treatment of pediatric feeding disorders. Intervention occurred at an intensive multidisciplinary day program designed for children with chronic and severe feeding difficulties meeting criteria for ARFID, specifically those with limited oral intake (i.e., dependence on enteral feeding, oral nutritional formula supplementation, or growth failure). Although intensive multidisciplinary intervention is increasingly recognized as the standard of care for children with complex feeding disorders, there remains the need to better document therapeutic approaches occurring in this setting (Sharp et al., 2017).

Table 3. Description of modified-bolus placement application (N = 23).

Variable	n (%)
Presentation method	
Flipped spoon	16 (69.6)
Nuk brush	7 (30.4)
Therapeutic target	
Expulsion	14 (60.9)
Packing	4 (17.4)
Packing and expulsion	5 (21.7)

Patient Demographics

In this study, 23 of the 93 patients (approximately 25%) admitted for treatment of severe feeding disorders received an intervention package involving modified-bolus placement to target expulsion or packing. This most often involved the use of a flipped-spoon procedure (Sharp et al., 2012) targeting expulsion of food. Packing and the use of Nuk-brush presentations also represented therapeutic targets and tools (respectively) for some patients. There was significant variability in the number of days in treatment before we introduced the modified-bolus placement across participants. This variability was largely dependent on when the problematic feeding behavior emerged; however, the potential for other variables to influence our results cannot be ruled out. In all cases, treatment combined modified-bolus placement with well-established behavioral elements, including bite persistence (i.e., nonremoval of the spoon), reinforcement, and stimulus fading procedures (Sharp, Jaquess, et al., 2010). In this clinical practice, behavioral intervention provides the mealtime structure and permits data-driven decision making to identify those children who would most benefit from a modified-bolus placement due to persistent expulsion and/or packing.

An area for future research should be to better define patient characteristics (e.g., lack of lip closure, immature lingual patterns, nonfunctional lingual patterns) that best identify the subset of children with feeding disorders who are the most appropriate candidates for modified-bolus placement. Better patient characterization should also include ambulatory status, severity of general tone, history of aspiration, and delay in initiation of swallow for example. Our best estimate, using data available in the EMR, of

Figure 2. Median box plots showing distribution of expulsions (top panel), median packing (middle panel), and median grams consumed. *p* values are from the overall test of significant effect of time from the repeated-measures analysis of variance model on the ranked observations. Black dots represent the raw data.

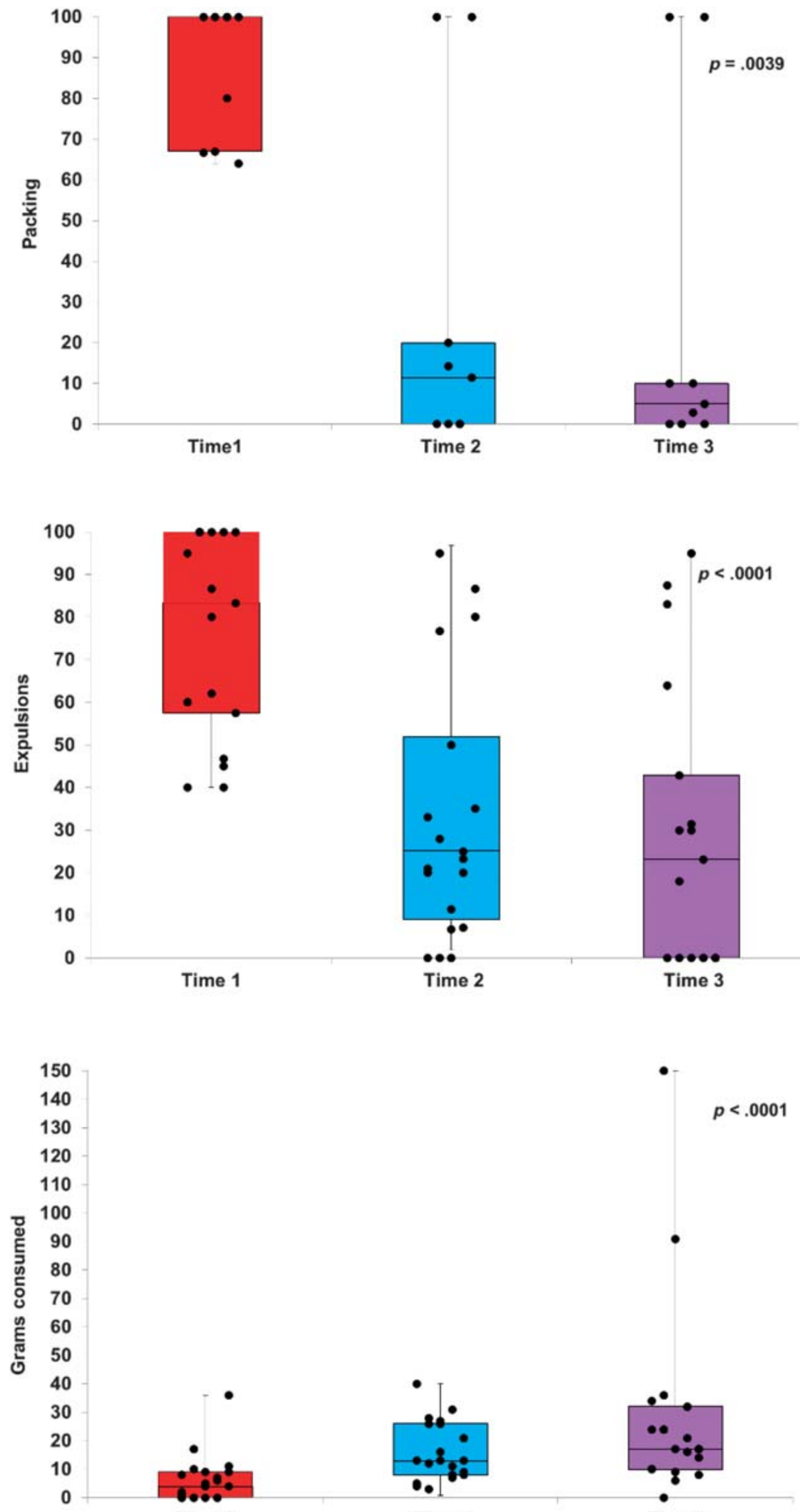


Table 4. Change in feeding behaviors by treatment time point (N = 23).

Variable	n	Time 1 (pre)	Time 2 (post)	Time 3 (Meal 5)	Median change	p^a
Expulsion, %	19	83.3%	23.3%	23.1%	Time 2 – Time 1: –39.0	< .0001
Mdn (25th–75th)		(55.7%–100%)	(7.1%–23.3%)	(0%–42.9%)	Time 3 – Time 1: –57.5	< .0001
					Time 3 – Time 2: 0.0	.746
Packing, %	9	100%	11.4%	5.0%	Time 2 – Time 1: –65.8	.011
Mdn (25th–75th)		(67.0%–100%)	(0.0%–20.0%)	(0.0%–10.0%)	Time 3 – Time 1: –80.0	.007
					Time 3 – Time 2: 0.0	.976
Grams consumed	21	4.0	13.0	17.0	Time 2 – Time 1: 9.0	< .0001
Mdn		(0.0–9.0)	(8.0–26.0)	(10.0–32.0)	Time 3 – Time 1: 13.5	< .0001
					Time 3 – Time 2: 4.0	.258

[a]Pairwise comparisons were made using a Wilcoxon signed-rank test.

ambulatory status for those patients with moderate-to-severe oral–motor skill deficits suggests 40% of those in the modified-bolus placement group were nonambulatory compared with 23% of those whose treatment only involved upright spoon. In addition, preliminary review of the data suggested that approximately 50% of patients whose oral–motor status was in the moderate-to-severe range had abnormal tone (low or high) regardless of modified-bolus placement. Our clinical assessment, however, did not include a formal evaluation of ambulatory status or tone beyond chart review, parent report, and clinical observation.

Oral–Motor Skill

An analysis of patient characteristics indicated that while medical comorbidities (e.g., gastroesophageal reflux disease, prematurity) were common across patients admitted into the day program, all patients who received modified-bolus placement presented with moderately to severely impaired oral–motor skills. Both procedures involved placement of the bolus directly onto the midblade of the tongue. The therapeutic benefits of modified-bolus placement may be attributed to assistance in bolus collection and formation, decreasing the effort and multiple motor component coordination (i.e., the lips, cheeks, tongue, jaw) needed to propel the bolus posteriorly in preparation for the swallow. In addition, the benefits were immediate with the modified-bolus technique, and there was no change between Time 2 and Time 3, suggesting an immediate compensatory rather than rehabilitation response. However, modified-bolus placement is limited because it is intended for use with pureed foods only.

Of note, research to date focuses exclusively on the potential therapeutic benefit of modified-bolus placement for compensating for oral–motor skill deficits. An important area of inquiry moving forward is to determine the impact of modified-bolus placement on the sensory side of the therapeutic picture. For example, understanding how repeated contact with different utensils and presentation methods involving different levels of pressure and movement on the tongue (e.g., wiping with the flipped spoon, rotating motion with the Nuk brush) contribute to a patient's response and rate of recovery during intervention is needed.

Our coding system for assessing oral–motor functioning was designed for use in our clinical practice, and further research scrutiny is needed to validate this clinical tool, especially the BOME. The BOME has not been shown to correlate or have any relationship to nutritive oral–motor abilities and requires psychometric validation beyond face validity. It remains unclear the exact mechanism of action that may lead to changes to oral–motor and sensory aspects of the swallow associated with these procedures given the acknowledged limitations of this chart review and the extant literature on this topic. Finally, future research should expand data collection procedures and include oral–motor examinations at each treatment time point to better document continued areas of strength and deficits.

Mealtime Performance Variables

In addition to documenting the context and overall use of modified-bolus placement, results provide insight into the possible therapeutic benefits associated with the use of these procedures. Prior to the use of modified-bolus placement, expulsion and/or packing occurred at high levels (median > 80% of bites) for affected patients. Once introduced, patients displayed significant improvement in mealtime performance that appeared durable after five subsequent treatment meals. Thus, our results lend additional support for the use of bolus placement using a flipped spoon or Nuk brush as a potential means to reduce expulsion and/or packing and improve consumption during meals in certain patients with feeding disorders. Both procedures promote contact with food and set the stage for more distal therapeutic goals (e.g., weaning from tube feedings) and possibly compensate for oral–motor concerns as posited in previous case reports (e.g., Girolami et al., 2007; Sharp et al., 2012).

A limitation of the current analysis is that we do not have information about the behavior of children who may not have responded well to the modified-bolus placement intervention. In addition, greater clarity regarding the clinical decision pathways that result in the adoption of a particular therapeutic approach (e.g., flipped spoon vs. Nuk) is needed. This reflects the broader need to develop a systematic and standardized approach to intervention to support systematic evaluation through prospective randomized clinical trials (Sharp et al., 2017). Unfortunately, data available in the retrospective review during routine clinical practice did not permit this level of clarity.

Return to Upright-Spoon Presentation

Although this study represents the most comprehensive analysis of modified-bolus placement to date, a number of important questions remain unanswered. First, all patients who remained in contact with the clinic following discharge successfully transitioned back to an upright spoon, which is a therapeutic trajectory documented in previous case reports (e.g., Sharp et al., 2012). The mechanism(s) associated with modified-bolus placement that promotes bolus management and permits stable consumption with an upright spoon, however, remains elusive. This includes how these procedures influence tongue coordination, food retention, lip or tongue retraction, and/or mouth closure—all key skills in becoming a proficient eater. The nature of retrospective data collection from the EMR limited variables available for analyses.

In summary, this study lends additional support for the use of modified-bolus placement in the treatment of pediatric feeding disorders, particularly among patients with moderate-to-severe oral–motor deficits. Results suggest a relatively simple therapeutic modification (i.e., direct placement of the bolus onto the tongue) can have immediate and meaningful therapeutic impact when expulsion and/or packing of food interfere with consumption. Treatment involved patients with some of the most pronounced disruptions in eating that required admission to an intensive multidisciplinary day program for treatment of severe feeding disorders that met psychiatric criteria for ARFID. As a therapeutic tool, modified-bolus placement may set the stage for more distal treatment outcomes, such as the transition from enteral to oral feeding. Given the potential therapeutic benefits associated with modified-bolus placement for this patient population, more rigorous evaluation of these procedures is clearly warranted.

References

Beckman, D. A. (1986/2013). *Beckman Oral Motor Assessment and Intervention*. Maitland, FL: Beckman & Associates.

Beckman, D. A. (2004). *Beckman Oral Hypersensitivity Scale*. Maitland, FL: Beckman & Associates.

Campbell, J. M. (2003). Efficacy of behavioral interventions for reducing problem behavior in persons with autism: A quantitative synthesis of single-subject research. *Research in Developmental Disabilities, 24,* 120–138. https://doi.org/10.1016/S0891-4222(03)00014-3

Crapnell, T. L., Rogers, C. E., Neil, J. J., Inder, T. E., Woodard, L. J., & Pineda, R. G. (2013). Factors associated with feeding difficulties in the very preterm infant. *Acta Paediatrica, 102,* e539–e545. https://doi.org/10.1111/apa.12393

Delaney, A. L., & Arvidson, J. C. (2008). Development of swallowing and feeding: Prenatal through first year of life. *Developmental Disabilities Research Reviews, 14,* 105–117. https://doi.org/10.1002/ddrr.16

Field, D., Garland, M., & Williams, K. (2003). Correlates of specific childhood feeding problems. *Journal of Paediatrics and Child Health, 39,* 299–304. https://doi.org/10.1046/j.1440-1754.2003.00151.x

Girolami, P. A., Boscoe, J. H., & Roscoe, N. (2007). Decreasing expulsions by a child with a feeding disorder: Using a Nuk brush to present and re-present food. *Journal of Applied Behavior Analysis, 40,* 749–753. https://doi.org/10.1901/jaba.2007.749-753

Hyman, P. E. (1994). Gastroesophageal reflux: One reason why baby won't eat. *The Journal of Pediatrics, 125,* S103–S1099. https://doi.org/10.1016/S0022-3476(05)82933-6

Kerwin, M. E. (1999). Empirically supported treatments in pediatric psychology: Severe feeding problems. *Journal of Pediatric Psychology, 24,* 193–214. https://doi.org/10.1093/jpepsy/24.3.193

Lukens, C. T., & Silverman, A. H. (2014). Systematic review of psychological interventions for pediatric feeding problems. *Journal of Pediatric Psychology, 39,* 903–917. https://doi.org/10.1093/jpepsy/jsu040

Piazza, C. C., Fisher, W. W., Brown, K. A., Shore, B. A., Patel, M. R., Katz, R. M., . . . Blakely-Smith, A. (2003). Functional analysis of inappropriate mealtime behaviors. *Journal of Applied Behavior Analysis, 36,* 187–204. https://doi.org/10.1901/jaba.2003.36-187

Sharp, W. G., Berry, R. C., Cole-Clark, M., Criado, K. K., & McElhanon, B. O. (2016). Assessment of feeding disorders in ASD: A multidisciplinary approach. In J. L. Matson (Ed.), *Handbook of assessment and diagnosis of autism spectrum disorder*. Basel, Switzerland: Springer.

Sharp, W. G., Harker, S., & Jaquess, D. L. (2010). Comparison of bite-presentation methods in the treatment of food refusal. *Journal of Applied Behavior Analysis, 43,* 739–743. https://doi.org/10.1901/jaba.2010.43-739

Sharp, W. G., Jaquess, D. L., Morton, J. F., & Herzinger, C. V. (2010). Pediatric feeding disorders: A quantitative synthesis of treatment outcomes. *Clinical Child and Family Psychology Review, 13,* 348–365. https://doi.org/10.1007/s10567-010-0079-7

Sharp, W. G., Jaquess, D. L., Morton, J. F., & Miles, A. G. (2011). A retrospective chart review of dietary diversity and feeding behavior of children with autism spectrum disorder before and after admission to a day treatment program. *Focus on Autism and Other Developmental Disabilities, 26,* 37–48.

Sharp, W. G., Odom, A., & Jaquess, D. L. (2012). Comparison of upright and flipped spoon presentations to guide treatment of food refusal. *Journal of Applied Behavior Analysis, 45,* 83–96. https://doi.org/10.1901/jaba.2012.45-83

Sharp, W. G., Stubbs, K. H., Adams, H., Wells, B. M., Lesack, R. S., Criado, K. K., . . . Scahill, L. D. (2016). Intensive manual-based intervention for pediatric feeding disorders: Results from a randomized pilot trial. *Journal of Pediatric Gastroenterology and Nutrition, 62,* 658–663. https://doi.org/10.1097/MPG.0000000000001043

Sharp, W. G., Volkert, V. M., Scahill, L., McCracken, C. E., & McElhanon, B. (2017). A systematic review and meta-analysis of intensive multidisciplinary intervention for pediatric feeding disorders: How standard is the standard of care. *Journal of Pediatrics, 181,* 116–124.e4. https://doi.org/10.1016/j.jpeds.2016.10.002

Stubbs, K. H., Volkert, V. M., Rubio, E. K., & Ottinger, E. (2018). A comparison of flipped spoon presentation and redistribution to decrease packing in children with feeding disorders. *Learning and Motivation, 62,* 103–111. https://doi.org/10.1016/j.lmot.2017.03.007

Vaz, P. C. M., Piazza, C. C., Stewart, V., Volkert, V. M., & Groff, R. A. (2012). Using a chaser to decrease packing in children with feeding disorders. *Journal of Applied Behavior Analysis, 45,* 97–105. https://doi.org/10.1901/jaba.2012.45-97

Volkert, V. M., Patel, M. R., & Peterson, K. M. (2016). Food refusal and selective eating. In J. Luiselli (Eds.), *Behavioral health promotion and intervention in intellectual and developmental disabilities* (pp. 137–161). Basel, Switzerland: Springer International Publishing.

Volkert, V. M., & Piazza, C. C. (2012). Pediatric feeding disorders. In P. Sturmey & M. Hersen (Eds.), *The handbook of evidence based practice in clinical psychology* (Vol. 1, pp. 456–481). Hoboken, NJ: Wiley. https://doi.org/10.1002/9781118156391.ebcp001013

Wilkins, J. W., Piazza, C. C., Groff, R. A., Volkert, V. M., Kozisek, J. M., & Milnes, S. M. (2014). Utensil manipulation during initial treatment of pediatric feeding problems. *Journal of Applied Behavior Analysis, 47,* 694–709. https://doi.org/10.1002/jaba.169