ASHA American Speech-Language-Hearing Association

PERSPECTIVES

SIG 13

Research Article

Feeding Skill and Behavior Changes in Children With Complex Feeding Disorders Following Therapy in an Intensive Multidisciplinary Feeding Program

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ARTICLE INFO

Article History:
Received December 15, 2021
Revision received February 25, 2022
Accepted April 18, 2022

Editor-in-Chief: Mary J. Sandage
Editor: Kendrea L. (Focht) Garand

https://doi.org/10.1044/2022_PERSP-21-00331

ABSTRACT

Purpose: This study aims to measure and describe changes in oral feeding skills and mealtime behaviors observed in children with complex feeding disorders and/or feeding tube dependence after participation in an intensive multidisciplinary feeding program. This is the first study to use a standardized tool to report feeding outcomes after patients received intensive feeding therapy using a combination of therapeutic strategies.
Method: This was a prospective observational study examining the treatment outcomes of 34 patients (range: 13 months to 6.5 years) admitted into the Intensive Multidisciplinary Feeding Program using the Pediatric Eating Assessment Tool (PediEAT). Eighteen patients were tube dependent; 16 patients were oral feeders. All patients received 19 days of intensive feeding intervention. The PediEAT was completed by patient's caregiver at admission and discharge from the feeding program. Caregiver and patient demographics were also collected.
Results: Statistical analysis of scores at admission (prescore) and at discharge (postscore) revealed significant improvements in PediEAT total scores and across all subscales for all patients. The largest degree of change was noted in the Problematic Mealtime Behaviors subscale. Patients who were oral feeders also demonstrated significant improvements in the Oral Processing subscale in addition to Problematic Mealtime Behaviors subscale. Tube-dependent patients presented with a large degree of change in the Selective Restrictive Eating subscale and in the Problematic Mealtime Behaviors subscale.
Conclusions: This study demonstrates that the use of an individualized approach using a combination of therapeutic strategies results in statistically significant improvements in multiple feeding domains as measured by a validated tool after participating in an intensive multidisciplinary feeding program. Improvement in a child's ability to manage advanced textures and consistencies can have a significant impact on their willingness to engage in mealtimes. It is important to measure and report on their skills, in addition to behavioral responses and intake.

Pediatric feeding disorders (PFDs) involve difficulties in accepting and consuming an age-appropriate diet orally, significantly impacting growth and development. The annual prevalence of PFDs has been estimated to be between one in 23 and one in 37 children under the age of 5 years in the United States (Kovacic et al., 2021). Children with comorbidities have a higher prevalence of PFDs, estimated to be between one in three and one in five children under age 5 years. Proposed definitions for PFDs highlight four areas that contribute to persistent feeding challenges: medical, nutritional, feeding skills, and psychosocial (Goday et al., 2019). The major challenges in pediatric patients with feeding disorders include (a) inadequate

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volume intake, (b) poor food variety, (c) oral aversion, (d) inefficient oral motor skills, and (e) negative mealtime behaviors (Piazza, 2008; Sharp et al., 2017).

Negative mealtime behaviors are a focus in caregiver descriptions of feeding disorders because they are disruptive and highly noticeable. These behaviors can include food refusal, distraction, elopement, or aggression (Linscheid, 2006). The underlying reason for a behavior can be difficult to discern. For example, texture intolerance due to dysfunctional oral sensory processing may present as selective eating or food refusal. This has led to a lack of consensus about the optimal therapeutic approach to PFDs. The most common treatment approach for disruptive behaviors cited in the literature is behavioral intervention (Sharp et al., 2017) with use of various techniques such as positive reinforcement, extinction, stimulus shaping, and fading (Gosa et al., 2017). Behavioral treatment may be performed in conjunction with oral motor and/or hunger provocation strategies and nutritional education (Sharp et al., 2017). Programs that use a combination of approaches, including nutritional, sensory, and behavioral approaches and hunger provocation (Cornwell et al., 2010; Sadeh-Kon et al., 2020; Williams et al., 2017), have reported outcomes such as the percentage of tube weaning, nutritional intake, mealtime duration, and patient weight. Bandstra et al. (2020) used a behavioral feeding protocol and a structured treatment hierarchy to promote oral motor skill development and desensitization but evaluated only acceptance of bites, mealtime behaviors, and feeding tube weaning not changes in oral sensory processing or oral motor skills. Volkert et al. (2014) used a clinical protocol to increase chewing and decrease early swallowing in three children. However, it was unknown if the children developed true chewing skills (including lateralization and rotary chew) to break down meats and fibrous vegetables presented, as this skill was not assessed. Marshall et al. (2018) reported increased acceptance of a variety of textures, indicating possible improvements in oral motor skill development with intervention. Only one study used validated tools in addition to measuring oral caloric intake to assess changes in parent/child interactions and observable mealtime behaviors following behavioral intervention (Silverman et al., 2013). The authors of previously published reviews have concluded that the concurrent use of a variety of feeding therapy strategies results in improved outcomes (Chawner et al., 2019; Gosa et al., 2017; Howe & Wang, 2013; Taylor et al., 2019).

As the body of literature for treatment of this population grows, there is converging support for evidence that intensive multidisciplinary treatment in a day treatment or inpatient hospital setting results in the most favorable and successful outcomes for children with complex feeding disorders (Sharp et al., 2017, 2020; Taylor et al., 2019). The treatment outcomes reported commonly are proportion of patients weaned from tube feeding, number of bites accepted, mealtime behaviors, weight changes, and caregiver stress (Sharp et al., 2017; Taylor et al., 2019). While these metrics are valuable, they do not provide specific information regarding the progress of the child's oral sensory motor skills, physiologic responses to food, or improved adaptive responses that are necessary to achieve the targeted volume of oral intake.

This study aims to measure and describe the changes in oral feeding skills and mealtime behaviors observed in children with complex feeding disorders and/or feeding tube dependence after participation in an intensive multidisciplinary feeding program. This is the first report on use of a standardized tool to analyze outcomes achieved with an individualized approach utilizing a combination of therapeutic feeding strategies.

Method

Study Design and Participant Selection

This was a prospective observational study of caregiver reported data following participation with their child in the Children's Health Orange County (CHOC) Intensive Multidisciplinary Feeding Program from February 2018 to November 2020. This study was approved by the CHOC Children's institutional review board with informed consent. The caregivers of all patients admitted to the program who met the Pediatric Eating Assessment Tool (PediEAT) age criteria (6 months to 7 years of age) were invited to participate in the study. Caregivers were defined as parents or extended family members with primary responsibility for feeding who would be present during the duration of the program. Extended family was defined as a family member chosen by parents who were involved in the caregiving of the patient in addition to the parents (e.g., grandparents). Extended family was incorporated into therapy if neither parent was unable to participate in the program. There was no control sample. Caregivers were recruited for the study by a research assistant who was not directly involved with other aspects of the study. Consent was obtained from caregivers who participated in the program and asked to complete the (PediEAT) on their first day of admission and on the day of discharge. Additionally, caregiver and patient demographics were collected.

Description of the Multidisciplinary Feeding Program

Patients were referred to the multidisciplinary feeding program by their gastroenterologists, by their community feeding therapists, and via self-referral. Prior to admission to the program, patients were evaluated by a multidisciplinary team in an outpatient clinic to determine

readiness and appropriateness for an intensive program prior to admission. The multidisciplinary team consisted of a gastroenterologist, a nurse practitioner, a dietitian, a speech-language pathologist (SLP), an occupational therapist (OT), a psychologist, and a social worker. The patient's nutrition, oral motor and swallowing skills, sensory processing, and mealtime behaviors were assessed, in addition to examining the family's coping and support systems. Candidacy for the program was determined by readiness factors including medical clearance by primary care physician, developmental level of > 24 months and failure to progress in outpatient feeding therapy. Developmental skills were informally evaluated via review of developmental history and the ability of patient to follow directions and to understand cause/effect and positive reinforcement strategies. If the patient met program criteria, they were deemed appropriate for an inpatient admission (Brown et al., 2014).

The CHOC Multidisciplinary Feeding Program is an intensive 19-day inpatient admission to CHOC Children's Hospital, which is a freestanding tertiary care pediatric hospital in Orange County, California. The program uses a multidisciplinary team approach to treat feeding disorders in children, including tube feeding dependence, difficulties transitioning to age-appropriate food textures, and food refusal. The team is composed of members from gastroenterology, nursing, rehabilitation, nutrition, psychology, and social work (see Table 1). During patient and caregiver participation in the program, direct intervention (feeding therapy) was provided by feeding therapists (SLPs and OTs) 3 times per day (1-hr sessions) for the duration of the program. The caregivers were responsible for practicing the various feeding strategies at two to three nontherapeutic mealtimes per day, when feeding therapist was not present, beginning on the day of admission. The patients were separated from the caregiver for individual therapy sessions during the first week. Caregivers were expected to watch each session remotely. There was a psychologist or a social worker present with the caregivers at some sessions to describe the therapeutic process and answer questions. The feeding therapists worked directly with each patient to meet individualized feeding goals set by the caregivers and therapists, including measures to address oral sensory motor deficits and to decrease negative mealtime behaviors. Caregivers were reintroduced at mealtimes during the second week, with direct real-time training via verbal direction and modeling by the feeding therapist. Therapist support gradually decreased over time, with use of verbal prompts to the caregivers remotely via an earpiece as the caregivers gained confidence to lead meals independently. By the third week, the caregiver led most of the meals with minimum support from the therapist via an earpiece and/or were having meals with their child out of the therapy room (e.g., in the cafeteria) to generalize new skills in the context of additional variables (e.g., with other family member(s), noisy environment). Caregivers were considered competent if they were able to implement the feeding strategies used during treatment sessions during nontherapeutic mealtimes to meet patient's feeding goals. Details of the program's procedures are outlined in a previous publication (Brown et al., 2014).

Description of Direct Therapeutic Intervention

As part of the individualized treatment approach for each patient, barriers to oral feeding were identified at the

Table 1. Disciplines of team members and roles.

Team member	Role
Gastroenterologist/nurse practitioner	Do medical management of patient during admission. Oversee tube weaning recommendations.
Registered dietitian	Calculate calorie and hydration goals. Review daily food logs. Complete daily calorie count. Assess weight trends. Provide caregiver education on portion sizes and meal planning. Assist in determining optimum nutrition intake. Provide nutrition goals at discharge.
Feeding therapist (SLP/OT)	Formulate patient's oral feeding goals. Lead therapeutic mealtime sessions 3 times/day. Determine appropriate strategies to use during therapeutic mealtimes (oral motor, oral sensory, sensory, and behavioral). Provide direct education to caregivers regarding therapy strategies.
Psychologist	Provide caregiver education regarding behavioral strategies. Observe nontherapeutic mealtimes sessions via videorecording and provide direct feedback.
Clinical social worker	Assist caregiver and patient with adjustment to inpatient admission to the program. Provide support to caregiver to improve coping and self-care. Observe nontherapeutic mealtimes sessions via videorecording and provide direct feedback. Support caregiver and patient with transition to home and school at discharge.

initial outpatient evaluation, and goals were formulated to address deficits. The specific strategies used during each therapy session were dependent on each patient's barriers and needs. Strategies were modified during the meal or as the patient demonstrated positive responses to the intervention. The therapists used a combination of common feeding strategies that are described below, with examples of how they may have been used.

Behavioral Intervention

Behavioral strategies have been reviewed extensively in the literature and shown to have positive outcomes in increasing oral intake in children with feeding difficulties. There are two types of behavioral treatment interventions: operant conditioning and exposure therapy. Operant conditioning focuses on the use of reinforcement and consequences. Exposure therapy interventions are behavioral strategies used to break patterns of avoidance and fear (Dumont et al., 2019). The premise for these interventions is that feeding difficulties stem from a learned response, which persists when a child receives positive attention and/or is allowed to escape from the mealtime environment (Taylor et al., 2019). In this study, various behavioral strategies were used to positively reinforce appropriate behaviors and responses. As the program is designed to develop sustainable positive mealtime experiences, specific escape extinction intervention known as nonremoval of the spoon was not applied despite previous reports of improved food acceptance outcomes (Taylor et al., 2019). Table 2 provides definitions of the various behavioral intervention strategies used broken down into the categories of operant conditioning and exposure therapy.

Positive reinforcement strategies using external reinforcers were used during treatment sessions. Examples of external reinforcers include verbal praise, social interaction, turn-taking during activities, stickers, and access to preferred food or toys. Reinforcement may have been immediate or delayed, depending on the patient's response. Immediate reinforcement was provided if the patient demonstrated significant stalling or refusal. If the patient was engaged in the meal, demonstrated willingness to comply, and has appropriate cognition, delayed reinforcement was used. The food may have been modified (cut down to a tiny piece, made into a fun shape, offered with a utensil, etc.) to make the task appear less threatening and to encourage a positive response. Shaping was used to encourage the patient to achieve target goals. For example, if the patient placed the food between their teeth and applied light pressure to make "teeth marks," that behavior was positively reinforced as a transitional step toward biting off a piece of food. As the patient was observed to increase acceptance of a novel food, lag schedules were implemented, with positive reinforcement offered only when the patient accepted a larger bite or took more bites than before. In some cases, stimulus fading was used to set behavioral expectations. With this strategy, the patient is expected to comply with an achievable expectation to end the interaction with a specific (often nonpreferred) food or to be able to end the therapeutic mealtime session. Expectations might have been to take one more bite of a food than the child was already observed to have consumed or to tap the food on the lips if the aversive response was significant.

For patients who presented with significant aversion to novel foods or textures, systematic desensitization was used by offering the food with increased frequency to gradually allow the patient increased familiarity. Oral sensorimotor skill level was taken into consideration to determine consistencies of food offered. Minimum expectations were initially set to encourage acceptance and were increased when the patient demonstrated adaptive responses. For example, initially interacting with the food with fingers or hands may progress to allowing the food on the lips, then the teeth, then the tongue, and onward until a small volume was consumed. Positive reinforcement was implemented upon performance of a targeted behavior. In some cases, food was modified depending on the response of the patient by changing the size of the bite (portion fading) and/or food texture (texture fading). To increase overall volume, the expectation of targeted behavior increased over time from the point of initial food acceptance (demand fading). In any given therapy session, several of the behavioral strategies described above were used to encourage oral acceptance.

Oral Motor Skills

Oral motor strategies are manual intervention, direct guidance, stretches, and oral desensitization used to teach specific skills to manage various textures and consistencies (Gosa et al., 2017). In this study, oral motor techniques were used initially for patients who demonstrated difficulty coordinating lip, jaw, and tongue movements to functionally manage a specific food consistency. For example, a Nuk brush was sometimes used to facilitate tongue lateralization and consecutive biting patterns prior to offering food on the molar surfaces in order to teach early chewing skills. The majority of oral motor skill work occurred as patients were taught to manipulate real foods in the mouth.

Sensory Processing

Sensory strategies are used to manage behaviors of a patient who has difficulties processing sensory information to act in an appropriate and successful manner in response to a demand. Interventions target underlying sensory processing difficulties rather than specific behaviors to decrease sensory defensiveness (Addison et al., 2012). If a patient had been identified as having a consistent sensory need (e.g., difficulty sitting and attending at mealtime secondary to proprioceptive and vestibular challenges) or sensory aversion (e.g., gagging with solid food consistencies),

Table 2. Behavioral intervention strategies used.

Operant conditioning	• Escape extinction: procedures that prevent escape from the feeding situation. Expectations are set that are readily achieved by the child. The child must comply with basic expectation to leave the table and be done with the meal (e.g., take one sip of liquid to finish the meal and clean up) • Differential reinforcement of alternative behavior: positive reinforcement of targeted desirable behaviors (e.g., reinforced with stickers, toys, and verbal phrase) on a variable schedule, as further described below (immediate or delayed). Also called differential attention • Immediate reinforcement: positive reinforcement that is provided with minimal time between the child's performance of the target behavior and the presentation of the reinforcer (e.g., giving a high-five immediately after child picks up one piece of food and places in their mouth) • Delayed reinforcement: positive reinforcement that is provided with increasing intervals of time between the child's performance of the target behavior and the presentation of the reinforcer (e.g., giving a high-five after child picks up and places in their mouth three consecutive pieces of food) • Noncontingent reinforcement: reinforcement not dependent on completing a target behavior (e.g., swallowing a nonpreferred food item) • Lag schedules: schedule of reinforcement in which a single response, or a sequence of responses, is reinforced if it varies from previous responses or sequences of responses (e.g., reinforcement for removing food from spoon with tongue and lips when previous response was licking food from spoon) • Shaping: positively reinforcing attempts at the target behavior that successively become closer to achieving the target (e.g., making teeth marks in an apple slice when target behavior is biting through the apple)
Exposure therapy	• Systematic desensitization: method to reduce avoidance behaviors towards an adverse stimulus by gradually increasing exposure to it • Stimulus/texture fading: gradually changing the texture of a food (e.g., offering IDDSI Level 4 eggs, then offering IDDSI Level 5 eggs) • Portion fading: gradually increasing a portion of a new food (e.g., increasing from 1/8-tsp volume on a spoon to 1/4-tsp volume on a spoon) • Demand fading: gradually increasing behaviors required by a participant (e.g., one bite to three bites) • Simultaneous presentation: type of flavor–flavor conditioning that pairs a nonpreferred food with a preferred food or liked condiment (e.g., dipping a cucumber in ranch dressing and assuming ranch is preferred) • Using new foods similar to those previously accepted (e.g., offering string cheese when shredded cheese is accepted) • Modeling: demonstrating the desired behavior (e.g., therapist puts food on their tongue and shows patient how they move food over to molar surface in their own mouth) • High probability sequences: asking patient to complete a high probability task (e.g., put spoonful of preferred food in mouth) before asking to perform a low-probability task (e.g., put nonpreferred food in mouth) • Choice of food: allowing a choice between different nonpreferred foods (e.g., allow patient to choose to taste either a new type of cracker or a nonpreferred fruit) • Access to preferred food: preferred food offered before the nonpreferred food is presented (e.g., having cup of preferred liquid readily available to sip while introducing a new solid food)

Note. IDDSI = International Dysphagia Diet Standardisation Initiative; tsp = teaspoon.

specific interventions were used to meet the individual need of the patient. A patient might require jumping activities prior to mealtime or during breaks in the meal to attend to mealtime tasks or might need to taste small crumbs before accepting a piece of solid food. Sensory strategies were often used in conjunction with behavioral strategies to increase acceptance while facilitating a positive response to the food.

Food Selection

Significant attention was given to selecting the foods that were offered at each of the patients' mealtimes, as these were a key therapeutic tool for oral sensory adaptations and oral motor skill progression. Food selection was made in close collaboration with the family, taking into consideration their home diet and the patient's current oral motor abilities, texture acceptance, and sensory needs (i.e., temperature and flavor profile). Use of modified consistencies according to the International Dysphagia Diet Standardisation Initiative (IDDSI) was considered on an individual basis. If the patient was not yet able to coordinate oral motor patterns to safely or efficiently accept an age-appropriate diet, then food items were prepared accordingly. For example, if a 5-year-old patient had difficulty managing a solid table food such as whole pieces of French toast, a Level 5 (Minced and Moist) or Level 4 (Pureed) consistency of the French toast was offered. The same food can be offered in two different consistencies: Level 4 (Pureed) and Level 7 (Regular) to address biting/chewing skills while simultaneously working on increasing oral intake with an easier consistency. As a patient's coordination and endurance improved, the consistency of foods offered was advanced. Foods offered during mealtimes struck a balance between foods that the patient could consume in volume with current oral motor skills and foods that built skills, with the knowledge that volumes of those foods would be small.

Caregiver Education/Training

Caregiver education and training are critical for successful generalization of the progress made during therapy

sessions. Systematic reviews suggest that parent-directed education for children with feeding disorders is moderately to strongly effective in increasing competence and improving parent–child interactions (Howe & Wang, 2013). In this study, heavy emphasis was placed on supporting caregivers' understanding of each therapeutic strategy used and delineating antecedent behaviors that prompted the use of each strategy. Caregivers all received extensive training via indirect and direct observation, video review of mealtimes, and direct feedback via an earpiece. The admission protocol supported transition of the caregiver from indirect to direct observational roles (within the treatment room) to the role of primary feeder (with guidance from the therapist). This guided participation approach develops skills through past, present, and anticipated experiences (Pridham et al., 2005), facilitating the caregiver's ability to support the child's development of new skills. Regardless of the overall progress made during an admission, caregivers were responsible for sustaining the new expectations at home upon discharge from the program.

Measures

PediEAT scores were used to evaluate caregiver perception of changes in the domains of physiologic symptoms, problematic mealtime behaviors, selective/restrictive eating, and oral processing. The PediEAT is a 78-item instrument validated for use in children 6 months to 7 years of age with feeding difficulties who are offered solid foods orally (Thoyre et al., 2018). The Physiologic Symptoms subscale consists of 27 items related to feeding difficulties (e.g., swallowing dysfunction, respiratory regulation, and gastrointestinal [GI] difficulties). The Problematic Mealtime Behaviors subscale consists of 23 items measuring mealtime behaviors such as refusals, increased mealtime duration, and throwing food. The Selective/Restrictive Eating subscale includes 15 items related to sensory processing and food selectivity, such as acceptance of various textures of food. The Oral Processing subscale has 13 items that assess oral sensory motor skills such as pocketing, difficulty chewing, and prolonged chewing (Pados, 2019).

Statistical Analyses

The frequency and proportion of clinical and demographic attributes were reported to describe all patients and caregivers. A Shapiro–Wilk test was used to test the normality of the distribution of all data vectors included in this analysis. A paired t test was used to test differences between pre- and post-intervention clinical endpoints if data met the Shapiro–Wilk test criterion of normality ($p > .05$). A paired Wilcoxon signed-ranks test was applied to those data where the null hypothesis of normality was rejected. Continuous variables were analyzed using a paired t test for normally distributed data. If the data did not follow normal distribution, as determined by the Shapiro–Wilk test, a paired Wilcoxon signed-ranks test was used. Cohen's d was performed to provide a measurement of the magnitude of effect of the intervention. The output yielded by Cohen's d represents the number of standard deviations by which two data vectors differ. Statistical tests were applied to provide evidence of significant difference in feeding intervention endpoints from baseline to post intervention observations. An alpha criterion of $< .05$ was used for both paired t test and paired Wilcoxon signed-ranks test. R statistical language 4.02 was used for this analysis.

Results

Forty-seven families were admitted to the program during the study period. Eight patients were excluded from the study because they did not meet the age criteria for the PediEAT. One patient's scores were excluded from the study as behaviors requiring psychiatric support increased in frequency during the study period. One family declined to participate, two families were missed for recruitment, and one family discharged prior to program completion, resulting in a total of 34 participants.

Patient age ranged from 13 months to 6.5 years (M = 4.2 years); 59% of the study patients were male, and 41% were female. In addition, 68% of patients were born at full term, whereas 32% were born prematurely. At the time of admission, 27% of patients had received a diagnosis of autism spectrum disorder. Furthermore, 42% of patients had a GI diagnosis noted by a GI provider. This included a history of, or current gastroesophageal reflux, eosinophilic esophagitis, vomiting, or constipation. Patient and caregiver characteristic information details are reported in Table 3.

The patients who completed the program during this time were all referred for and diagnosed with a PFD as described by Goday et al. (2019). For the purpose of describing patient baseline feeding status for the reader, we grouped them broadly into four categories: (a) tube dependent and accepting < 50% oral volumes; (b) tube dependent and accepting > 50% oral volumes; (c) all oral feeders and accepting liquids and purees only; and (d) all oral feeders and accepting all textures. Of our 34 patients, 18 were tube dependent (16 had a gastrostomy tube [GT], and two had an indwelling nasogastric tube [NGT]) and 16 were oral feeders. Of the patients receiving nutrition via tube, 14 were meeting less than 50% of their nutritional needs orally, and four were meeting more than 50% of their nutritional needs orally. Of the patients who were

Table 3. Characteristics of patients and caregivers.

Patient (*N* = 34)	***n***	**%**
Male	20	59
Gastrostomy tube	16	47
Nasogastric tube	2	6
Oral	16	47
Full term	23	68
Premature	11	32
Medical diagnosis		
History of gastroesophageal reflux	9	27
Eosinophilic esophagitis	1	3
Constipation	4	12
Developmental delay		
Autism	9	27
Genetic disorder	4	12
Speech problems	5	15
Caregiver (*N* = 34)	***n***	**%**
Education		
Professional degree	14	54
College/university	6	23
Technical school	5	19
High school	2	8
Two-parent household	31	91
Family income ≥100,000	20	77
Age at admission	***M***	***SD***
Patient	4.2 years	1.3
Caregiver	37.5 years	5.2

oral feeders, eight were eating liquids and purees only, and eight were eating and drinking some foods of all textures.

PediEAT scores from day of admission to the program (considered the prescore) and day of discharge from the program (considered the postscore) were compared. Decreases in scores signify improvements in each subscale. Full report of clinical endpoints for PediEAT subscales for all patients and subsets can be found in Table 4. All participants had statistically significant improvements in total score and in all subscales of the PediEAT. The mean total score decreased from 146.1 to 102.8 over the study period ($p < .0001$). The PediEAT subscale with the largest degree of change was the Problematic Mealtime Behaviors subscale with a mean prescore of 64.8 and mean postscore of 42.4 ($p < .0001$).

For subanalysis, patient scores were divided into an oral feeding subset ($n = 16$) and a tube feeding subset that included GT and NGT feedings ($n = 18$). In the oral feeding subset, the highest degree of change was in the Problematic Mealtime Behaviors subscale (Cohen's $d = 1.4$) followed by the Oral Processing subscale (Cohen's $d = 0.86$). In the tube feeding subset, the highest degree of change was also in the Problematic Mealtime Behaviors subscale (Cohen's $d = 1.23$) followed by the Selective Restrictive Eating subscale (Cohen's $d = 0.7$).

In the Oral Processing subscale, there was a larger degree of improvement in the oral feeding subset (Cohen's $d = 0.86$) than in the tube feeding subset

Table 4. Distribution of clinical endpoints for PediEAT subscales.

All patients				
Variable	**Prescore mean (*SD*)**	**Postscore mean (*SD*)**	**Cohen's *d***	***p* value**
Physiologic symptoms	23.7 (14.86)	15.8 (11.6)	0.59	.0001
Problematic mealtime Behaviors	64.8 (18.2)	42.4 (15.9)	1.3	< .0001
Selective restrictive eating	33.0 (9.8)	25.5 (10.4)	0.73	.0001
Oral processing	24.7 (9.4)	19.1 (7.8)	0.65	.0001
Total score	146.1 (37.8)	102.8 (37.3)	1.15	< .0001
Oral feeding subset				
Variable	**Baseline mean (*SD*)**	**Post-intervention mean (*SD*)**	**Cohen's *d***	***p* value**
Physiologic symptoms	23.6 (14.8)	14.1 (9.3)	0.76	.002
Problematic mealtime behaviors	70 (17.9)	44.8 (17.6)	1.4	< .0001
Selective restrictive eating	35.6 (8.3)	27.8 (11.0)	0.79	.009
Oral processing	24.1 (9.0)	17.1(6.8)	0.86	.006
Total score	152.8 (34.7)	103.8 (37.1)	1.36	< .0001
Tube feeding subset (GT and NGT)				
Variable	**Baseline mean (*SD*)**	**Post-intervention mean (*SD*)**	**Cohen's *d***	***p* value**
Physiologic symptoms	23.8 (15.3)	17.3 (13.4)	0.45	.01
Problematic mealtime behaviors	60.2 (17.7)	40.2 (14.3)	1.23	< .0001
Selective restrictive eating	30.7 (10.7)	23.4 (9.7)	0.7	.008
Oral processing	25.3 (9.9)	20.8 (8.4)	0.48	.005
Total score	140.1 (10.4)	101.9 (38.6)	0.96	< .0001

Note. PediEAT = Pediatric Eating Assessment Tool; GT = gastrostomy tube; NGT = indwelling nasogastric tube.

(Cohen's d = 0.48). In the Selective Restrictive Eating subscale, the degree of change was nearly the same for the oral feeding subset (Cohen's d = 0.79) and the tube feeding subset (Cohen's d = 0.7). While improvements were statistically significant in the Physiologic Symptoms subscale in both groups, this was the subscale with the least degree of change. Notably, the Cohen's d value for the tube feeding subset was 0.45 (p = .01), indicating that the effect of this intervention on the Physiologic Symptoms subscale was smallest in those patients receiving tube feeds.

Discussion

The results from this prospective observational study demonstrate that the use of an individualized approach utilizing a combination of therapeutic feeding strategies results in decreased symptoms of feeding problems in PediEAT total and subscale scores after completion of an intensive inpatient feeding program. A previous publication by this program reported outcomes such as nutrition and weight changes in a different cohort (Brown et al., 2014; Kim et al., 2020) but not specific skill and behavior outcomes as measured using a validated tool. Previous systematic reviews have also concluded that multicomponent interventions are the most beneficial approach to the treatment of PFDs. Lukens and Silverman (2014) noted that combining nutritional intervention, structured mealtime schedules, oral motor intervention, and caregiver training with behavioral strategies is the most effective method to treat feeding disorders in children. Behavioral interventions such as positive reinforcement, extinction, and systematic desensitization were found to be helpful when used in conjunction with other strategies (e.g., oral motor) to improve compliance with skill building. (Clawson & Elliott, 2014). Clawson and Elliott concluded that providers using single-therapy approaches may overlook underlying factors contributing to the feeding problem. Another review found evidence for the use of systematic desensitization and operant conditioning to improve food intake and the variety of foods consumed and to decrease problematic behaviors (Gosa et al., 2017). Our findings support the use of multicomponent therapeutic interventions to improve mealtime participation, behaviors, oral skills, and acceptance of increased food consistencies.

Patients completing the program were observed to have the greatest improvement in problematic mealtime behaviors. Decreased frequency was observed for behaviors including talking to avoid eating, eating better when being entertained, throwing food, preferring to drink instead of eating, and discontinuing the meal after eating only a few bites. Children with persistent feeding difficulties often present with learned feeding avoidance secondary to history of negative feeding and/or mealtime experiences. Addressing underlying behaviors is paramount for the therapist to then also work with the patient toward improvement in oral sensory motor skills for successful oral feeding (Gosa et al., 2020).

Scores in the Oral Processing subscale also decreased significantly in all patients, indicating that oral sensory and oral motor skills improved over the course of the intensive feeding program. Caregivers observed decreased frequency of storing food in cheeks or roof of the mouth, increased frequency of chewing instead of spitting food out, and increased acceptance of varied food textures and presentation. There are limited studies that report change in oral motor skills as a treatment outcome measure following intensive feeding therapy. The outcomes of multidisciplinary intensive feeding programs are frequently reported in terms of bite acceptance, behaviors, and volumes consumed using empirically researched behavioral strategies (Sharp et al., 2016). Children with complex feeding disorders may demonstrate increased negative behaviors because they experience challenges managing certain textures/consistencies if they have not developed sufficient skills (Sheppard, 2011), making assessment of oral processing skills imperative in consideration of causes for a child's feeding disorder. Our results indicate that using a combination of therapeutic feeding strategies to address mealtime participation while simultaneously addressing oral sensory motor skill development improves acceptance of a variety of food textures and consistencies.

The oral feeding subset demonstrated a larger degree of improvement in oral processing skills than the tube feeding subset. Children who are tube dependent typically are noted to have more complex medical comorbidities compared to children without feeding tubes (Jackson et al., 2022). This finding may be attributed to a medical history significant for an underlying medical etiology in the patients who relied on supplemental tube feedings that resulted in persistent oral aversion. The patients in the oral feeding subset also demonstrated higher foundational oral motor skills at admission with much more time spent eating orally than the patients with feeding tubes, which may contribute to the larger degree of improvement in oral processing.

In addition to improvements in the Problematic Mealtime Behaviors subscale, decreased scores in the Selective Restrictive Eating subscale was noted in the tube feeding subset. Patients who are tube dependent present with limited acceptance of age-appropriate food consistencies and variety possibly because of limited exposure and opportunities to learn about these foods. A combination of therapeutic feeding strategies focusing on positive mealtime experiences, increasing exposure to a variety of food textures and temperature to improve acceptance, was shown to increase oral sensory motor skills as indicated

on the Selective Restrictive Eating subscale. The oral feeding subset did not make as large a change in this subscale, possibly because of increased resistance to foods they have already developed preferences against through repetitive aversive responses, whereas the tube fed patients have no preferences for or against foods they have not been exposed to.

While all patients had large degrees of improvement from the prescore to the postscore, scores for the Physiologic Symptoms subscale were observed to have the smallest change during the program. This subscale addresses symptoms indicative of serious GI or respiratory concerns that would be treated and managed outpatient prior to admission to the program, resulting in less opportunity for large changes from pre- to post-intervention scores. Persistent physiologic symptoms such as gagging during mealtimes and gagging with textured food would be addressed over the course of the program.

Selection of Therapeutic Intervention

Despite the growing body of evidence surrounding many aspects of PFDs, there is no standardized method yet to determine optimal intervention type, frequency, and setting. This is due to vast heterogeneity in both the patient population and the models of service delivery. Given the complexity of PFDs, treatment approach must consider the individual child's strengths and needs in the areas of cognitive development, sensory processing, oral motor skill and swallow safety, and social–emotional needs. For example, prior to initiating therapy, oral and swallowing skills should be assessed to determine what consistencies the child can consume safely and efficiently. If the child demonstrates significant refusal when presented with a given food, the clinician needs to determine the reason for refusal. If the refusal is due to not wanting to eat the food, then a behavioral strategy would be used. However, if the child presents with a physiologic response to food (e.g., stress signs, and gagging), then a sensory strategy may be used. With careful analysis of these factors, treatment strategies can be appropriately selected to address the response. A child with neuromotor dysfunction may have oral motor skill deficits that require food to be pureed for nutritional needs to be met; other food consistencies may also be presented for practice with biting and chewing skills. In other cases, if purees are met with refusal behaviors, a child with an underlying sensory aversion may benefit from systematic desensitization and behavioral strategies. Both strategic approaches may be used during the same treatment session, with systematic desensitization to increase acceptance of nonpreferred texture and behavioral interventions with age-appropriate foods to target oral motor skill. It has been suggested that management should initially work within the child's existing abilities to increase volume accepted and variety; then, over time, the treatment team may work on skill development to increase food texture, efficiency, and self-feeding (Gosa et al., 2020).

Limitations

As there are limited studies on PFDs that consist of results derived from the use of a validated and reliable measurement tool, this study focused on utilizing a validated tool to measure caregiver perceptions of success. The PediEAT was selected as it may be used to ascertain information on a wide range of symptoms related to feeding difficulties. As the PediEAT is completed by a caregiver instead of a clinical therapist, measurement bias must be considered as a potential limitation in this study. To minimize bias, the PediEAT was completed by the same caregiver on both the day of admission and the day of discharge. The results were derived by comparing each patient's pre- and postscores individually instead of collectively. This model did not allow for a control group. Caregiver bias should be considered as well, as caregivers may have overstated or minimized scoring for a variety of reasons. Although all requirements for test administration were followed, there was a short length of time between the first and the last administration of the PediEAT, which may have created some test–retest bias. Lastly, this was a single-center study, and no attempt was made to control for the diversity of patient demographics.

Another limitation is the possible effects of indirect intervention provided by other disciplines during the program, resulting in decreased internal validity. Psychologists provide consultation to caregivers on use of strategies to decrease general behaviors outside of mealtimes, which could impact Problematic Mealtime Behavior subscale scores. The dietitian and medical team recommendations for tube feeding reductions upon admission to the program may contribute to improved participation during mealtimes, which, in turn, affect Mealtime Behaviors subscale scores and Oral Processing subscale scores if the patient is better able to engage in oral feeding attempts.

The results of this study can be generalized to other children with complex feeding disorders who demonstrate resolution of underlying medical etiology, which can contribute to the feeding challenges and who demonstrate cognitive ability to understand basic behavioral expectations. Caregiver involvement and training is essential to generalize skills to the home environment. However, the authors cannot exclude the indirect effect of education and feedback from the other disciplines in the feeding program on the improvements in scores across all domains outlined on the assessment measure.

Future Directions

There is literature supporting the benefits of utilizing a combination of behavioral, sensory, and oral motor strategies to target feeding difficulties; however, results obtained using validated assessment tools are significantly limited. Although this study used a validated assessment tool, implementation of a clinician-based assessment in future studies would provide additional information regarding specific discrete improvements in oral feeding skills and behaviors in children with complex feeding disorders. Measuring change in IDDSI levels as an index for oral skill development during treatment would also provide more objective information. It would also be important to measure the success of parent/caregiver carryover of taught strategies upon generalization to their home setting, as well as to collect long-term data pertaining to the progression or regression of feeding efficacy and mealtime behaviors.

Conclusions

Our results show that the use of a multimodal therapy approach results in statistically and clinically significant improvements across a variety of feeding domains, regardless of the complexity of the feeding disorder. The literature supports the use of multicomponent strategies for the treatment of PFDs. However, other publications have reported on nutrition and observed behavioral outcomes with only limited data regarding the contributions of the SLP or the OT. This article highlights the use of multiple feeding strategies, selected specifically to address a patient's individual barriers to eating, resulting in positive effects on oral processing and mealtime behaviors, as measured via a validated tool.

Improvement in a child's ability to manage advanced textures and consistencies can have a significant impact on their willingness to engage in mealtimes. It is important to measure and report on their skills, in addition to behavioral responses and intake. To our knowledge, our study is the first to report improvements in not only mealtime behaviors but also oral sensory and oral motor skills using a validated tool following intervention in an intensive feeding program.

Author Contributions

Hema Desai: Conceptualization (Lead), Methodology (Lead), Writing – original draft (Lead), Writing – review & editing (Lead). **Sarah Lauridson:** Investigation (Equal), Writing – original draft (Equal), Writing – review & editing (Equal). **Michelle Nguyen:** Writing – original draft (Supporting), Writing – review & editing (Supporting). **Elisa Ornelas:** Data curation (Supporting), Formal analysis (Lead), Writing – review & editing (Supporting). **John Schomberg:** Formal analysis (Lead).

Acknowledgments

The authors would like to thank Children's Health Orange County (CHOC) Children's Hospital and the CHOC Multidisciplinary Feeding Program for their support, as well as Rachel Davis for her expertise and assistance.

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