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Effect of a new treatment protocol called Functional Chewing Training on chewing function in children with cerebral palsy: a double-blind randomised controlled trial

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SUMMARY **Cerebral palsy (CP) is a group of permanent sensorimotor impairments. Children with CP have various feeding difficulties including chewing disorder, which may affect their nutritional status. Functional Chewing Training (FuCT) was designed as a holistic approach to improve chewing function by providing postural alignment, sensory and motor training, and food and environmental adjustments. This study aimed to investigate the effect of FuCT on chewing function in children with CP. This study was designed as a double-blind, randomised controlled trial. Eighty CP children with chewing disorder were randomised and split between the FuCT group (31 males, 19 females; mean age 3·5 ± 1·9 years) and the control group (16 males, 14 females; 3·4 ± 2·3 years) receiving traditional oral motor exercises. Each group received the training programme for 12 weeks with weekly follow-up and with two evaluations at baseline and end of 12 weeks. Chewing function was evaluated by analysing video recordings and scored with the Karaduman Chewing Performance Scale (KCPS). The Behavioral Pediatrics Feeding Assessment Scale (BPFAS) was used to evaluate feeding behaviours of children. A significant improvement was observed in KCPS scores at 12 weeks after training in the FuCT group ($P < 0·001$), but no change was found in the control group ($P = 0·07$). A significant improvement was detected in all parameters of BPFAS at 12 weeks after training in the FuCT group ($P < 0·001$) and in four parameters of BPFAS in the control group ($P = 0·02$, $P = 0·02$). FuCT is an effective method to improve chewing function compared with traditional oral motor exercises.**

KEYWORDS: chewing, cerebral palsy, feeding disorder, chewing exercise, rehabilitation

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Background

Cerebral palsy (CP) is a nonprogressive neurological disorder that affects the brain and results in problems with muscle coordination, body movement and balance. Children with CP often present with feeding impairments secondary to these severe motor impairments (1). Feeding is a broad spectrum that includes several dimensions of eating such as bolus preparation, chewing and swallowing (1). Common feeding problems that need to be solved in children with CP are choking with food (56%), feeding time greater than 3 h per day (28%), frequent vomiting (22%) and chewing difficulty (26%) (2, 3).

Chewing function, which is part of the feeding process, is defined as a rhythmic oral motor activity to comminute and soften solid food (4). Children with CP often have difficulty in bolus formation and effective chewing and have limited ability to manage age-appropriate food textures (2). The specific nature and severity of the chewing dysfunction may differ in relation to sensorimotor impairment and gross and fine motor limitations of patients with CP (5). The most affected parts of chewing are food transportation

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from the front of the mouth to the molar area and food processing by a series of masticatory cycles because of insufficient lateral and rotational tongue movements in patients with CP (5). Thus, children with chewing dysfunction are unable to take any solid food although the diet of normal developing children with normal feeding skills includes liquid, semisolid and/or solid foods together (2, 5). This inability may limit sufficient food intake and the nutritional status of children. The significance of this situation is that nutritional status affects growth, general health and quality of life of children and their families (6). Therefore, it is important to improve chewing function and provide solid food intake in children with CP.

No consensus has been formed on how to manage chewing problems in rehabilitation. In literature, some studies have been conducted on different strategies, such as modelling, oral motor therapy and encouragement, among others (7–10). These interventions demonstrate potential benefits for chewing problems in children with CP, but the current level of evidence is poor. However, the use of evidence-based interventions in treatment is important to develop additional effective interventions to improve functions and quality of life of patients and their families. Thus, randomised controlled trials for the management of chewing problems are required.

Our clinical experiences show that a functional approach is needed to improve chewing function. Functional training refers to train the related body part for the targeted function and continuing practicing that functions in everyday living. Improved results during follow-up are obtained with functional training (11). Chewing is a function that consists of a series of rhythmic oral motor activities including biting, lateral and rotational tongue movements, even elevation and retraction of the tongue, and swallowing. Thus, we considered that improving the chewing function without a functional approach is not possible and that repeated positive and successful experiences may be the key for learning how to chew. We designed a holistic approach called Functional Chewing Training (FuCT), which includes providing postural alignment, sensory and motor training of chewing, and food and environmental adjustments together. The study aimed to investigate the effects of FuCT on chewing function in children with CP. We hypothesised that FuCT could improve chewing function in children with CP.

Methods

The study was held at Hacettepe University with the cooperation of the Physical Therapy and Rehabilitation Department and Swallowing Disorders Research and Application Center. The study was approved by Hacettepe University Non-invasive Clinical Research Ethics Committee (approval date and number: 3 September 2014, GO 14/417-45). The study was conducted in accordance with the World Medical Association Declaration of Helsinki. This study was designed as a double-blind, randomised controlled trial of FuCT in CP compared with traditional oral motor exercises.

Participants

Parents of all children provided their written informed consent. Children with CP who had complaints about chewing function and could not manage solid food intake above the age of 18 months were included. The most specific complaints reported by the parents were solid food refusal, holding food in the mouth, trying to mash the food between tongue and palate, choking, gagging and pushing the food out of their mouths during recruitment. Children who were below the age of 18 months and used any medicine and/or oral appliances that could affect chewing performance were excluded. Children with CP were recruited from the Hacettepe University Swallowing Disorders Research and Application Center.

Procedure

Eighty CP children with chewing disorder were subsequently randomised and split between the FuCT group and the control group using a randomised sampling, which was computer generated with a basic random number generator. The allocation ratio was 5:3 for the study and control groups. Among 80 participants, 50 were randomised into the FuCT group and 30 into the control group.

Intervention

The FuCT was designed to improve chewing function according to 15 years of clinical experiences. Our clinical experiences show a need for a functional approach to improve chewing function. The FuCT includes combined treatment strategies including two

domains: impairment-based (positioning the child and food, sensory stimulation and chewing exercise) and adaptive (food consistency) components. The protocol aimed to ensure functional improvement in chewing function by stimulating and teaching the function. The steps of the FuCT are shown in Table 1. The FuCT is a holistic approach that includes therapy sessions (steps 1, 3 and 4) and daily rules (steps 1, 2 and 5). It takes 20 min to complete.

The control group received traditional oral motor exercises including passive and active exercises of lips and tongue. Passive exercises include passive range of motion exercises of lips and tongue. The movement is provided with the assistance of the parents. The exercises aim to normalise feeding patterns by providing sensory input, facilitating normal muscle tone, and reducing abnormal oral reflexes. Active exercises include an active range of motion and strength training of lips and tongue. The exercises aim to ensure chewing force by increasing the strength of the oral motor structures (12–14). This approach also takes 20 min.

An experienced physical therapist was responsible for teaching the training programmes of the FuCT and control group to the parents. A standardised brochure for each training programme was given to the parents to follow the same routine. The FuCT and the traditional oral motor exercises were performed five sets in a day and 5 days a week over a period of 12 weeks as a home programme. Sets were arranged at the same time of the day and followed by a time chart. Parents were informed about the treatment protocols but were not aware of the randomisation. The exercises were followed up by phone every week by the same physical therapist who gave the training to the parents. After every 4 weeks of the exercises, the physical therapist controlled the programme in the clinic.

Evaluations

Descriptive characteristics, including age, height, weight, transition time to additional food, meal time, number of meals, initial teething time and number of teeth, were noted. The presence of open mouth, open bite, high palate, gag reflex and oral hygiene were scored as absent or present as an observational oral motor assessment (15). Open mouth is the spontaneous opening of the lips at rest. Open bite is the situation in which the upper and lower incisors do not meet. A palate that is unusually high and narrow is called a high palate. Gag reflex is a reflex contraction of the back of the throat evoked by touching the back of the tongue. Oral hygiene is performed to keep the mouth and teeth clean. The Behavioral Pediatrics Feeding Assessment Scale (BPFAS) was used to evaluate the feeding behaviours of the children and parent behaviours associated with poor nutritional intake.

Table 1. The steps and description of the Functional Chewing Training

The steps of the Functional Chewing Training	Description
Step I (Positioning the child)	A proper head and trunk control is essential to ensure smooth chin and lip closure and facilitate tongue movement. Thus, the proper head and body position is important to promote more effective and safe eating in children (10). The child was placed in a sitting position with the body tilted 60–90° tilted and head in neutral position, and the arms and legs supported
Step II (Positioning the food)	The food was suggested to place through the corners of lips to the molar area during every meal. Positioning the food to the lateral sides inhibits abnormal reflexes that interfere with safe feeding, stimulates and consolidates the chewing function
Step III (Sensory stimulation)	The lack of sensory experience is also affected chewing function. Thus, the application includes massaging the upper and lower gums from the front teeth to molar area. This sensory stimulation facilitates lip closure, tongue lateralisation and rotary chewing to inhibit tongue thrust and decrease tactile hypersensitivity and encourage chewing function
Step IV (Chewing exercise)	The most important rehabilitation part in the FuCT is the chewing exercise. A chewing tube was placed in the molar area of the child and the caregiver moved the tube from one side of the mouth to other side, and chewing function was executed. The exercise can be promoted by increasing the hardness of the material. Training and strengthening of the chewing function can provide greater opportunities to learn and practice feeding skills
Step V (Adjustment of food consistency)	The degree of food consistency was increased gradually to support the exercises and improvement

The BPFAS is a 35-item standardised, reliable and valid parent-completed screening tool. Each item is rated on a five-point Likert scale based on the frequency with which particular behaviours occur. The scale's eight subscales are total frequency score, child frequency score, parent frequency score, total problem score, child problem score, parent problem score, restriction score and poor strategies. The frequency scores reflect how often a behaviour occurs, and the problem scores represent the number of problematic feeding behaviours. Higher scores for both frequency and problems are an indication of worse mealtime functioning (16). Chewing function was also evaluated by analysing video recordings. All chewing sessions were recorded using a camera (Sony HDR-PJ410 Handycam Camera, Weybridge, Surrey, UK), which was placed at a distance of 100 cm, for 3–5 min. Each child was placed in a sitting position (either on a chair or on his/her mother's arm) with the head upright and with the midline position and arms and legs supported. The sessions were conducted in a quiet environment. Each child was required to bite and chew a standardised biscuit, and no clue was given on how to chew. All video recordings were scored using the Karaduman Chewing Performance Scale (KCPS) (17). The KCPS is a valid, reliable, quick and clinically easy-to-use functional instrument for determining the level of chewing function in children. It classifies chewing function on an ordinal scale with five levels between 0 and 4 based on the sequence of functional movements during chewing. In the instrument, '0' means normal chewing function, and '4' means no biting and chewing. Outcome measures were evaluated in a standardised manner at baseline and after the intervention (week 12) by another experienced physical therapist blinded to the group allocation of the children.

Statistical analysis

Statistical analysis was performed using IBM-SPSS for Windows version 20*. Descriptive statistics was calculated as a number/per cent (*n*/%) for qualitative data and mean ± standard deviation for quantitative data. The normality assumption was checked by the Shapiro–Wilk's test for test selection. The differences between the FuCT and control groups were analysed using the chi-squared test for categorical variables (sex, oral motor assessment parameters and KCPS) and the Mann–Whitney *U*-test for continuous variables (age, height, weight, transition time to additional food, meal time, number of meals, initial teething time, number of teeth and BPFAS). The Wilcoxon signed-rank test was used to compare the differences between baseline and post-intervention scores within groups. A *P*-value of less than 0·05 was considered to show a statistically significant result.

*IBM Corp., Armonk, NY, USA.

Results

Eighty CP children with chewing disorder were randomised and split between the FuCT group (31 males, 19 females; mean age 3·5 ± 1·9 years; min = 1·5, max = 10) and the control group (16 males, 14 females; mean age 3·4 ± 2·3 years; min = 1·5, max = 11), which received traditional oral motor exercises. The descriptive characteristics are shown in

Table 2. The descriptive characteristics of the children (*N* = 80)

Descriptive characteristics	FuCT group (*n* = 50) X ± s.d.	Control group (*n* = 30) X ± s.d.	*P*
Age	3·5 ± 1·9	3·4 ± 2·3	0·30
Height	89·83 ± 12·85	85·70 ± 14·12	0·16
Weight	12·91 ± 4·15	12·04 ± 3·40	0·46
Transition time to additional food (month)	6·90 ± 3·01	6·18 ± 2·79	0·30
Meal time (min)	31·52 ± 30·07	44·14 ± 39·21	0·22
Number of meals	5·84 ± 6·19	4·48 ± 1·27	0·32
Initial teething time (month)	8·43 ± 3·06	8·88 ± 4·29	0·96
Number of teeth	19·73 ± 1·11	19·60 ± 1·29	0·31
	n (%)	*n* (%)	
Sex			
Female	19 (38)	14 (46·7)	0·45
Male	31 (62)	16 (53·3)	
Oral motor assessment parameters			
Open mouth	19 (38)	15 (50)	0·29
Open bite	12 (24)	11 (36·7)	0·23
Tongue thrust	18 (36)	15 (50)	0·22
High palate	26 (52)	18 (60)	0·49
Oral hygiene problems	38 (76)	25 (83·3)	0·44
GAG reflex	49 (98)	28 (93·3)	0·29

Table 3. The baseline scores of the children in terms of the Behavioral Pediatrics Feeding Assessment Scale and Karaduman Chewing Performance Scale (N = 80)

	FuCT group (n = 50) X ± s.d.	Control group (n = 30) X ± s.d.	P
The Behavioral Pediatrics Feeding Assessment Scale			
Total frequency score	89·28 ± 20·79	96·97 ± 22·36	0·12
Total problem score	12·54 ± 5·79	14·10 ± 6·40	0·29
Child frequency score	63·66 ± 14·60	69·50 ± 16·29	0·10
Parent frequency score	25·62 ± 7·51	27·47 ± 7·59	0·27
Child problem score	8·82 ± 4·28	10·13 ± 5·04	0·27
Parent problem score	3·72 ± 2·08	3·97 ± 2·13	0·58
Restriction score	16·42 ± 5·41	17·57 ± 5·85	0·46
Poor strategies	9·86 ± 3·98	11·03 ± 3·80	0·18
	n (%)	n (%)	
Karaduman Chewing Performance Scale			
0	– (0)	– (0)	0·18
1	10 (20)	3 (10)	
2	11 (22)	8 (26·7)	
3	12 (24)	13 (43·3)	
4	17 (34)	6 (20)	

Table 2. No statistical differences were found between the groups (P > 0·05). Baseline data showed that each group was well matched in age, height, weight, sex, transition time to additional food, meal time, number of meals, initial teething time, number of teeth and oral motor assessment.

At baseline, no statistically significant differences were observed between the FuCT group and the control group in terms of chewing performance level (P = 0·24) and each BPFAS subscales (P > 0·05) (Table 3).

After 12 weeks, the FuCT group showed improvement in chewing performance according to the KCPS (P < 0·001) and in feeding behaviours according to the BPFAS (P < 0·001). The control group did not show any improvement in chewing performance (P = 0·07) but presented improvement in four subscales of the BPFAS, namely, total frequency score, total problem score, child frequency score and child problem score (P = 0·02, P = 0·03, P = 0·02, P = 0·01) (Table 4).

A significant difference was found between the FuCT group and the control group in favour of FuCT group in the KCPS levels, and in the BPFAS subscales except restriction score after 12 weeks of intervention (P < 0·001) (Tables 5 and 6).

Discussion

This study is the first double-blind randomised controlled study on the effect of the FuCT on the chewing function and feeding behaviours of children with CP who had chewing disorder. Our findings showed that the FuCT improves the chewing performance and mealtime functioning of children with CP.

Table 4. The scores of the Behavioral Pediatrics Feeding Assessment Scale and Karaduman Chewing Performance Scale before and after intervention in groups

	FuCT group (n = 50)			Control group (n = 30)		
	Before intervention X ± s.d.	After intervention X ± s.d.	P	Before intervention X ± s.d.	After intervention X ± s.d.	P
The Behavioral Pediatrics Feeding Assessment Scale						
Total frequency score	89·28 ± 20·79	69·14 ± 15·63	<0·001	96·97 ± 22·36	92·50 ± 19·49	0·02*
Total problem score	12·54 ± 5·79	4·48 ± 3·59	<0·001	14·10 ± 6·64	12·40 ± 5·52	0·03*
Child frequency score	63·66 ± 14·60	49·48 ± 11·07	<0·001	69·50 ± 16·29	65·73 ± 14·22	0·02*
Parent frequency score	25·62 ± 7·51	19·66 ± 5·60	<0·001	27·47 ± 7·59	26·77 ± 7·19	0·45
Child problem score	8·82 ± 4·28	3·12 ± 2·57	<0·001	10·13 ± 5·04	8·63 ± 3·93	0·01*
Parent problem score	3·72 ± 2·08	1·36 ± 1·34	<0·001	3·97 ± 2·13	3·77 ± 2·09	0·25
Restriction score	16·42 ± 5·41	14·9 ± 5·02	<0·001	17·57 ± 5·85	17·07 ± 4·91	0·14
Poor strategies	9·86 ± 2·98	7·56 ± 2·50	<0·001	11·03 ± 3·80	10·73 ± 3·68	0·53
	Median (25–75%)	Median (25–75%)	P	Median (25–75%)	Median (25–75%)	P
Karaduman Chewing Performance Scale	3 (2–4)	1 (0–1)	<0·001	3 (2–3)	3 (2–3)	0·07

*P < 0·05.

Table 5. The difference between groups in terms of the Karaduman Chewing Performance Scale after the 12th week of intervention

Karaduman Chewing Performance Scale	FuCT group (n = 50) n (%)	Control group (n = 30) n (%)	χ^2	P
0	21 (42)	– (0)	47·884	<0·001
1	24 (48)	6 (20)		
2	5 (10)	6 (20)		
3	– (0)	15 (50)		
4	– (0)	3 (10)		

The use of a variety of definitions to define chewing function and evaluation methods in the literature brings some challenges, thus making the comparison of study results is difficult. For instance, some studies defined chewing as an up and down motion of the jaw but did not consider tongue lateralisation and rotary jaw movement during chewing evaluation (8, 10, 18). Thus, the evaluation and results may be imprecise in reflecting the exact chewing performance and treatment outcomes. We chose to use KCPS, which analyses every step of chewing function, to classify the level of chewing (17). Using an appropriate evaluation instrument is important to show the baseline and post-intervention results correctly (19). Therefore, one of the strengths of the current study is its use of the KCPS to determine the functional chewing performance level of children.

Various training methods for chewing function are described in the literature (7, 8, 10, 12, 13). A study that focused on teaching chewing skills used a modelling method by modelling chewing with an audible 'crunch' and then asking a child to do the same thing (7), Eckman *et al.* also used a combination of shaping and fading (8), Shore *et al.* attempted to increase chews per bite using prompting, shaping and reinforcement (10) and Gisel *et al.* investigated the effects of oral motor treatment (12, 13). However, no consensus have been made on how to improve chewing function in children. The aforementioned studies have weak evidence because of a low sample size, the lack of control groups and unmatched evaluation methods and outcome measurements. The other strength of our study is that it is the first double-blind randomised controlled trial about chewing training.

Traditional oral motor exercises are the most preferred techniques to improve chewing function (12, 13). These exercises aim to improve mouth closure and tongue lateralisation through isolated passive and active muscle movements of lips and tongue (20). Therefore, we intended to show the effects of the FuCT on chewing function by comparing the FuCT with traditional oral motor exercises, which are currently used to improve chewing function. Each group was well matched in age, height, weight, sex, transition time to additional food, meal time, number of meals, initial teething time, number of teeth and oral motor assessment, which provided our comparisons reliable. Chewing function was improved with the FuCT, but the traditional oral motor exercise group did not show any improvement in terms of chewing performance level. The FuCT, which is a holistic approach, is based on the idea that training every single movement of a function separately to improve and learn a function is insufficient. Thus, the FuCT is designed to focus on the chewing function directly and it includes providing postural alignment, sensory stimulation for each bite, sensory and motor training of chewing function and finally encouraging children for more viscous food. The primary step of the FuCT is a proper head and body position to ensure smooth chin and lip closure and facilitate tongue movement

Table 6. The difference between groups in terms of the Behavioral Pediatrics Feeding Assessment Scale after the 12th week of intervention

	FuCT group (n = 50) X ± s.d.	Control group (n = 30) X ± s.d.	z	P
The Behavioral Pediatrics Feeding Assessment Scale				
Total frequency score	69·14 ± 15·63	92·50 ± 19·49	−4·713	<0·001
Total problem score	4·48 ± 3·59	12·40 ± 5·52	−5·663	<0·001
Child frequency score	49·48 ± 11·07	65·73 ± 14·22	−4·595	<0·001
Parent frequency score	19·66 ± 5·60	26·77 ± 7·19	−4·306	<0·001
Child problem score	3·12 ± 2·57	8·63 ± 3·93	−5·623	<0·001
Parent problem score	1·36 ± 1·34	3·77 ± 2·09	−5·067	<0·001
Restriction score	14·9 ± 5·02	17·07 ± 4·91	−1·729	0·084
Poor strategies	7·56 ± 2·50	10·73 ± 3·68	−3·934	<0·001

for more effective and safe chewing and swallowing. The aim of placing food in the molar area during every meal time and massaging the upper and lower gums from the front teeth to the molar area is to inhibit abnormal reflexes and stimulate lateral and rotatory tongue movements during chewing function. Performing chewing exercise was used to teach and practice the function. Gradually increasing food consistency consolidates the chewing experience safely. This holistic approach aims not only for experience but also for a successful experience in solid food intake because successful experiences in chewing support the improvement of the efficiency of chewing over time. Conversely, traditional oral motor exercises focus only on passive and active muscle movements of lips and tongue. This exercise regimen may improve isolated lip and tongue movements, but it is not efficient to improve the whole function and does not change the level of chewing performance. Another possible reason why the traditional oral motor exercise group did not ensure development in chewing function is that applying isolated movements to neurologically impaired children is difficult. Thus, the superiority of the FuCT compared traditional oral motor exercises is reasonable.

Another aspect of our current study is that we evaluated the feeding behaviours of children and parent behaviours associated with poor nutritional intake using BPFAS. We evaluated the feeding behaviours of children and related parent behaviours as chewing dysfunction could affect feeding behaviours and cause stressful mealtimes for caregivers and children (21). Thus, we expected to find that chewing treatment also improved mealtime behaviours of children and decreased the stress and concern level of parents about their children's feeding behaviours. The scores of the BPFAS subscales decreased in the FuCT group. This result indicates that mealtime functioning improved, and the stress and concerns of the children and their families changed to a positive direction by the improved chewing function. Only four subscales of the BPFAS, namely total and child frequency as well as total and child problem scores, decreased in the traditional oral motor exercise group. Mealtime functioning of children improved to a degree, while the stress and concern level of the parents about their children's feeding behaviours remained the same. Additionally, they presented lower scores in BPFAS, which showed that their mealtime behaviours were worse while the level of stress and concerns of families about their children's feeding behaviours were higher than the FuCT group. This result indicates that the traditional oral motor exercise group also gained some improvement in terms of mealtime functioning but the FuCT group still had better improvement.

The FuCT is a promising holistic approach to improve chewing function in children with CP. We conclude that the FuCT should be added to clinical practice in the management of chewing disorders.

Limitation

As the FuCT was found to be an effective treatment protocol for chewing disorders in children with CP, it should be considered that the training programmes were taught to parents to be applied as a home programme in our study design. This condition may be a limitation of this study despite the precautions in providing standardisation in the application of the training programme.

Future research

Future studies should focus on investigating the effects of the FuCT on chewing function in children with different diagnoses who have chewing disorders.

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