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Original Article

The Effects of Temporomandibular Joint Mobilization on Drooling Control, Swallowing Function and Quality of Life in Cerebral Palsy Patients; Double-Blind Study

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Abstract

Background: This study aimed to determine the effects of temporomandibular joint (TMJ) mobilization on saliva control, swallowing function, and quality of life in cerebral palsy (CP) patients with temporomandibular joint dysfunction (TMD).

Methods: A total of 20 patients who met the inclusion criteria and were between the ages of 1 and 18 years were included. They were then randomly divided into two groups. In the study group (n=10) patients were treated with TMJ mobilization in addition to control group treatments In the control group (n=10), patients were treated with physiotherapy, and a home program including passive joint movements was provided. The treatments were continued 2 sessions/ week and 6 weeks. Patients were evaluated using the Pediatric Functional Independence Measurement (WeeFIM), the Drooling Frequency and Severity Scale (DFSS), and the Assessment of Swallowing Ability and Function (SAFE).

Results: The difference between the SAFE scale scores before and after treatment was statistically significant ($p<0,05$). There were negative correlations between WeeFIM, and DFSS scores; a positive correlation between drool frequency and severity scores; a negative correlation between drool severity and mandible lateral deviation values; and a negative correlation between drool frequency and mandible protrusion values.

Conclusion: As a result, it was found that temporomandibular mobilization in patients with cerebral palsy with TMD has a positive effect on saliva and swallowing functions and quality of life.

Keywords: Cerebral Palsy, Temporomandibular Joint Dysfunction, Swallowing, Quality of Life, Mobilization

INTRODUCTION

Drooling is the uncontrolled and continuous release of saliva from the mouth. The swallowing reflex does not develop, and saliva aspiration is observed. Approximately 40% of patients with cerebral palsy experience drooling, contributing to high levels of physical and social-emotional morbidity. Drooling-caused problems are unpleasant smell, oral infections, hygiene problems, dehydration, and skin irritation. The quadriplegic cerebral palsy group represents the most common category experiencing chronic drooling (30%-53%) (1,2).

In dysphagia, more time and effort are spent to send solid or liquid foods from the mouth to the stomach. Dysphagia occurs in 2 out of 3 children with cerebral palsy, leading to complications such as dehydration, malnutrition, aspiration pneumonia, poor oral hygiene, a weakened immune system, the use of a tracheal tube, impaired quality of life, increased costs, and elevated mortality (3).

Pain, crepitation in the joint, and irregular mandibular function are observed in TMD. Ortega et al. reported that the rate of TMD patients is significantly higher in patients with CP (68%) compared to normal subjects (25%), and the clinical severity of CP increases the pathological findings of TMJ (4).

Drooling, dysphagia, low quality of life, and high TMD

prevalence are observed in patients with CP, and these symptoms emphasize the importance of diagnosis and evaluation (1-3). According to our knowledge, there is no study that evaluates and treats TMD, quality of life, drooling, and swallowing together in patients with CP in Turkish and global society.

The aim of this study was to determine the effects of TMJ mobilization on drooling, swallowing function, and quality of life in CP patients with TMD.

METHODS

Study Design

A randomized controlled double-blind study design was used. The measurements of the study were carried out by a blind physiotherapist, and the physiotherapist generated the random allocation sequence, assigned participants to interventions, and enrolled participants. The participants also blindly participated in the study. In addition, statistical analysis of the study was done by a blind biostatistics specialist.

Participants

Our study was conducted at Birlikcan Private Education and Rehabilitation Center in Istanbul, involving 20 voluntary patients with cerebral palsy (CP) and temporomandibular joint disorders (TMD) within the age range of 1 to 18 years. Patients who had a wound in the mouth that hindered treatment, who were allergic to gloves, or who had an additional disease were not included. Participants were divided into two groups randomly. In the control group (n=10), patients were treated with physiotherapy and a home program, including passive joint movement. In the mobilization group (n=10), patients were treated with TMJ mobilization in addition to control group treatments. The treatments were continued for 2 sessions per week for 6 weeks. Evaluations and treatments were carried out face-to-face and individually.

Ethical Considerations

The ethical approval for the study was obtained from Istanbul Okan University's Social and Non-Interventional Health Sciences Research Ethics Committee. Additionally, permission was obtained from the Private Birlikcan Special Education and Rehabilitation Center. To comply with ethical principles in our study, informed consent was obtained from all participants' families, and they were assured that all information would remain confidential.

Data Collection

Before and after treatment, TMJ function, saliva control, swallowing function, and the quality of life of the participants were evaluated.

Data Collection Tools

Evaluation was conducted before and after treatment. Inclinometer

Active and passive joint movements of the TMJ were evaluated using an inclinometer. In mandible protrusion measurement, the lower incisors should be positioned in front of the upper incisors. The mandible was manually advanced, and subsequent measurements were taken. The movement was completed when resistance was felt, and the head began to move forward. The lower incisors should be 6-9 mm in front of the upper incisors. For mandible lateral deviation measurement, the distance between the upper and lower canines was measured using a ruler. It has been reported that the lateral deviation movement of the mandible can range between 6-10 mm. For passive mouth opening measurement, the distance between the upper and lower incisors was measured. The average range of motion (ROM) is between 43.5-52.1 mm (6).

Pediatric Functional Independence Measurement (WeeFIM) WeeFIM consists of six subsections and 18 items: personal care, sphincter control, transfers, movement, communication, social, and cognitive functions. Each item is scored from 1 (maximal assistance) to 7 (independent). Accordingly, a minimum score of 18 (fully dependent) and a maximum score of 126 (fully independent) can be obtained (7).

Drooling Frequency and Severity Scale (DFSS)

The DFDS scale is a subjective drooling scoring system used in otolaryngology and neurology. It was used to determine drooling levels pre- and post-salivary gland ablation. This scale contains a drooling frequency score ranging from 1 to 4 and a severity value ranging from 1 to 5. The minimum possible scale score is 2, and the maximum is 9.8.

Assessment of Swallowing Ability and Function (SAFE

SAFE was used to evaluate swallowing skills and functions. The scale has three subdimensions. In the physical evaluation of the oropharyngeal mechanism, the lips, tongue, palate, cheeks, teeth, mandible, larynx, and oral reflexes are evaluated (0: severe disorder, 1: moderate disorder, 2: mild disorder, 3: within functional limits). In the oral phase swallowing assessment, lip closure and tightness, tongue movements, chewing, and nasal backward flow were evaluated (using the same scoring method). In the other subdimension, delay in swallowing, laryngeal elevation, snagging and coughing, consecutive swallowing, voice change after swallowing, and the presence of backward flow were evaluated (9).

Treatment

Mobilization of TMJ is examined in 5 sections:

1. At the beginning of the range of motion (ROM), low-amplitude movement is applied to the sensitive joints. This technique works with neuromodulation.
2. In a part of the ROM, larger amplitude oscillation was applied.
3. At all ROM, high-amplitude oscillation was applied.

4. At the end of the ROM, low-amplitude movement was applied.
5. Manipulation moves the joints more than usual. It involves high-speed, low-amplitude movements (5).

Distraction of TMJ
The physiotherapist places the thumb on the lower molar teeth of the patient, and the other digits provide the mandible, and he/she pushes the TMJ forward directly with the thumb (5).

Anterior Glide of TMJ
Positioning is the same. The physiotherapist applies the first level of traction to the TMJ with the thumb, and he/she pulls the mandible forward while traction continues (5).

Medial Glide of TMJ
The physiotherapist places the thumb of both hands, perpendicular to each other, on the mandibular condyle of the joint, and he/she applies a push to the medial with the thumb (5).

STATISTICAL ANALYSIS

Statistical data were evaluated with IBM SPSS v22 and IBM SPSS AMOS v22 programs. Descriptive statistics (mean, standard deviation, median, number, percentage, etc.) were calculated in the evaluation of the data. The suitability of quantitative variables to normal distribution was examined using the Shapiro-Wilk Test. The difference between the groups in terms of quantitative variables was examined using the t-test for normal distribution and the Mann-Whitney U test for non-normal distribution. T-test was used in dependent samples for normal distribution variables, and the Wilcoxon test was used for non-normal distribution variables. Spearman correlation analysis was used to examine the relationship between quantitative variables. The difference between the qualitative variables between groups was examined by the Chi-square test. Cronbach's alpha coefficient was used for internal consistency in evaluating the reliability of the scale. The significance level was taken as $p < 0.05$.

RESULTS

The demographic characteristics of the patients are given in **Table 1**.

Table 1. Demographic characteristics according to groups

Features	Control Group (n=10)	Mobilization Group (n=10)	Statistical Evaluation
	Median (Min-Max)	Median (Min-Max)	
Height. cm	120.00 (75.00-163.00)	122.50 (95.00-165.00)	p=0.739
Weight. kg	21.00 (8.20-70.00)	22.50 (13.00-51.00)	p=0.971
Body mass index. kg/m^2	16.67 (10.96-31.82)	15.82 (11.52-21.53)	p=0.353
Gender*. n(%). Female Male	6 (%75.00) 4 (%33.33)	2 (%25.00) 8 (%66.67)	p=0.170
Age. year	7.25 (1.50-17.00)	7.50 (3.00-18.00)	p=0.631

The difference values of groups before and after treatment were shown in **Table 2**. There are no statistical differences between the groups in terms of WeeFIM scores, drooling frequency, and mandible lateral deviation values. The SAFE difference score of the mobilization group is higher than the control group, and the drooling severity, passive mouth opening, and mandible protrusion difference values of the mobilization group are more than the control group after the treatment

Table 3 shows the relationship between the pre- and post-treatment scales of the control group. When the table was examined, before the treatment, SAFE and passive mouth opening are correlated negatively. WeeFIM and mandible protrusion are correlated negatively, drooling severity and drooling frequency are correlated positively. After the treatment, SAFE and ROM of the mouth are correlated negatively, and drooling frequency and drooling severity are correlated positively.

Table 4 shows the relationship between the pre- and post-treatment scales of the mobilization group. Before the treatment, WeeFIM and drooling severity, frequency are correlated negatively. Drooling frequency and severity are correlated positively. Drooling severity and mandible lateral deviation are correlated negatively.

When the post-treatment section is examined, WeeFIM and drooling severity, frequency are correlated negatively. Drooling severity and frequency are correlated positively. Drooling severity and mandible lateral deviation are correlated negatively. Drooling frequency and mandible protrusion are correlated negatively.

DISCUSSION

When the literature is surveyed, our study, which investigates the effect of temporomandibular mobilization on saliva control, swallowing functions, and quality of life in patients with CP and TMJ dysfunction, is the first of its kind. We conducted a comprehensive analysis of the parameters, which were previously examined separately in the literature, for the first time. Studies on temporomandibular joint (TMJ) dysfunction in patients with cerebral palsy (CP) are limited.

In our study, TMD findings such as joint sensitivity, limited TMJ movements, deviation of the TMJ, and

Table 1. Demographic characteristics according to groups

Features	Control Group (n=10)	Mobilization Group (n=10)	Statistical Evaluation
	median (min-max)	median (min-max)	
SAFE	0.00 (0.00-3.00)	3.00 (2.00-3.00)	**p<0.001**
WeeFIM	3.00 (0.00-8.00)	5.50 (1.00-11.00)	p=0.281
Drooling Severity	0.00 (0.00-1.00)	1.00 (0.00-1.00)	**p=0.023**
Drooling Frequency	0.00 (0.00-0.00)	0.00 (0.00-1.00)	p=0.481
PassiveMouth*	0.20 (-0.20-0.80)	0.40 (0.20-0.50)	**p=0.023**
MandibleProt**	0.00 (-0.10-0.20)	0.10 (0.10-0.20)	**p=0.002**
MandibleLat***	0.00 (0.00-0.10)	0.00 (-0.10-0.10)	p=0.912

SAFE; swallowing ability and function. WeeFIM; pediatric functional independence measurement

muscle spasms were present. In our study, findings such as joint sensitivity, limited TMJ movements, deviation of the TMJ, and muscle spasms align partially with those reported by McNeill et al., who identified a broader spectrum of symptoms, including tinnitus, insomnia, and vertigo.

While McNeill's findings provide a comprehensive overview, our study emphasizes the functional aspects of TMD in CP patients, highlighting the direct implications for treatment strategies (10). According to the study of Bae et al., TMD was diagnosed when at least three of these criteria were found (11). Laskin et al. have determined the five criteria: facial pain, sensitivity with palpation on the chewing muscles, crepitations, limitations in mouth opening width or deviation, and radiographic findings (12).

In our study, limitations were seen in mandible protrusion, lateral deviation, and passive mouth opening measurements. Dinçer et al. also determined limitations in ROM of the mandible in TMD, and the results were parallel with our study (13).

In line with Wieckiewicz et al., who identified manipulation and mobilization as primary treatments for TMD, our study further demonstrates the efficacy of these techniques specifically in CP patients with TMD. While Dinçer et al. focused on pain relief, our findings extend these results by showing improvements in swallowing function and quality of life, suggesting a multifaceted benefit of TMJ mobilization (13,14).

In the study of Purohit et al., they compared the effects of

Table 3. Evaluation of difference values of groups before and after treatment

Mobilization Group	Features	SAFE	WeeFIM	Drooling Severity	Drooling Frequency	Passive Mouth*	Mandibleprot**	Mandiblelat***
Before Treatments	SAFE	1.000						
	WeeFIM	r=-0.44 p=0.203	1.000					
	Drooling Severity	r=0.287 p=0.421	**r=-0.902 p<0.001**	1.000		symmetrical		
	Drooling Frequency	r=0.304 p=0.393	**r=-0.82 p=0.004**	**r=0.826 p=0.003**	1.000			
	PassiveMouth*	r=0.189 p=0.600	r=0.609 p=0.061	r=-0.488 p=0.153	r=-0.4 p=0.252	1.000		
	MandibleProt**	r=-0.024 p=0.947	r=0.158 p=0.663	r=-0.247 p=0.492	r=-0.35 p=0.322	r=-0.264 p=0.461	1.000	
	MandibleLat***	r=0.074 p=0.839	r=0.469 p=0.171	**r=-0.685 p=0.029**	r=-0.497 p=0.144	r=0.146 p=0.687	r=0.516 p=0.126	1.000
After Treatment	SAFE	1.000						
	WeeFIM	r=-0.179 p=0.622	1.000					
	Drooling Severity	r=0.196 p=0.587	**r=-0.755 p=0.012**	1.000		symmetrical		
	Drooling Frequency	r=0.035 p=0.923	**r=-0.654 p=0.04**	**r=0.849 p=0.002**	1.000			
	PassiveMouth*	r=0.353 p=0.317	r=0.454 p=0.188	r=-0.353 p=0.316	r=-0.193 p=0.594	1.000		
	MandibleProt**	r=0.468 p=0.173	r=0.178 p=0.624	r=-0.248 p=0.49	**r=-0.583 p=0.077**	r=-0.086 p=0.813	1.000	
	MandibleLat***	r=-0.337 p=0.341	r=0.277 p=0.438	**r=-0.789 p=0.007**	r=-0.577 p=0.08	r=0.208 p=0.563	r=0.021 p=0.955	1.000

Table 4. Relationship between the pre and post-treatment scales of the mobilization group

Mobilization Group	Features	SAFE	WeeFIM	Drooling Severity	Drooling Frequency	Passive Mouth*	Mandibleprot**	Mandiblelat***
Before Treatments	SAFE	1.000						
	WeeFIM	r=-0.44 p=0.203	1.000					
	Drooling Severity	r=0.287 p=0.421	**r=-0.902 p<0.001**	1.000				
	Drooling Frequency	r=0.304 p=0.393	**r=-0.82 p=0.004**	**r=0.826 p=0.003**	1.000			
	PassiveMouth*	r=0.189 p=0.6	r=0.609 p=0.061	r=-0.488 p=0.153	r=-0.4 p=0.252	1.000		
	MandibleProt**	r=-0.024 p=0.947	r=0.158 p=0.663	r=-0.247 p=0.492	r=-0.35 p=0.322	r=-0.264 p=0.461	1.000	
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	PassiveMouth*	r=0.353 p=0.317	r=0.454 p=0.188	r=-0.353 p=0.316	r=-0.193 p=0.594	1.000		
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	MandibleLat***	r=-0.337 p=0.341	r=0.277 p=0.438	**r=-0.789 p=0.007**	r=-0.577 p=0.08	r=0.208 p=0.563	r=0.021 p=0.955	1.000

mobilization and exercise on maximum mouth opening, and they found mobilization more effective consequently (15). The objectives and results of these studies are in line with our study.

Our findings that drooling and swallowing problems are interrelated align with Erkin et al., who highlighted the broader spectrum of nutritional and dental issues in CP patients. However, unlike Erkin's study, which primarily reported prevalence, our research focuses on treatment outcomes, demonstrating significant improvements in drooling severity and swallowing function through TMJ mobilization (16).

In the light of these studies, it has been observed that drooling, swallowing, TMJ, and tooth problems are related.

In alignment with Matthews et al., who emphasized the health and social impacts of drooling, our study provides evidence of improved quality of life metrics post-treatment. Additionally, our findings support Tcheremenska et al., who linked drooling to feeding challenges, by showing that addressing TMD can mitigate these issues and enhance functional independence (17).

Also, in the study of Tcheremenska et al., it was reported that 66.7% of children with CP cannot be fed solid food because of drooling (18). In the study of Mathisen et al., it was shown that oral motor control disorders, abnormal neurological development, and poor nutritional position cause disorders in swallowing function in patients with CP. Thus, they found that drooling, coughing, and prolonged eating time caused family anger, poor communication with the child, and reduced quality of life (19).

As a result of these studies, it is concluded that saliva control increases the functional quality of life, independence in self-care skills, and social skills.

Duman et al. found that patients with spastic quadriplegic CP have more drooling problems than other types, and drooling is more common at a young age (20). In our study, patients could not be evaluated according to CP types because of the low sample size.

In the study by Novak et al., CP was defined as a neurodevelopmental and motor disorder characterized by drooling, eating difficulties, and speech problems (21). Avivi-Arber et al. showed that CP is associated with sensory and motor dysfunction of the orofacial region, including dysarthria, dysphagia, chewing disorder, and drooling problems (22). According to this study, CP is a neurodevelopmental, sensory, and motor disorder. But in our study, we did not investigate the sensory area of problems.

In a recent study, it was determined that swallowing occurred in 90%, eating in 39-85%, drooling in 22-40%, and speech problems in 53-59% of children with CP (23). We observed that there were swallowing (90%) and drooling (40%) problems in the control and mobilization groups. These issues warrant serious attention, and

further studies are needed to address them.

According to Stalling et al., the prevalence of swallowing problems, which may result in dehydration, aspiration, and pneumonia, is associated positively with the severity of motor involvement (24). Rempel et al. observed that the incidence of swallowing difficulties, airway protection problems, positioning, assisted feeding, and prolonged feeding times increased in CP with oral motor effects (25). These studies emphasize that the severity of the disease is related to problems with long feeding times, aspiration, and pneumonia.

Philpot et al. showed that successful swallowing and chewing experiences support communication between the family and the child, and on the other hand, nutritional difficulties cause health and social stress between families and children (26). Guare et al. showed that periodontal disease and dental caries are observed in children with CP with oral motor effects (27). In our study, a significant increase was observed in the quality of life as a result of mobilization.In his studies.

Manno et al. showed that appropriate postural alignment facilitates swallowing, feeding, and speech processing. When neck stabilization is provided, control of the tongue and masticatory muscles will also be easier. Wrong sitting position causes increased trunk flexion and tonus, and this reveals the tonic bite reflex (28). In our study, posture analysis was not evaluated, but measurements were made with the head in a neutral position.

Alper et al. reported that hypotonia in the facial muscles causes an open mouth posture, stabilization of the TMJ facilitates the control of tongue movements, and limitation of TMJ movements reduces manipulation of food in the oral cavity (29). Hall et al. reported that elimination of temporomandibular joint problems, TMJ stabilization, control of tongue movements, and intense consistency food consumption reduce nutritional problems in patients with CP (30). In our study, the patients did not have the normal ROM of the TMJ, and these problems were seen.

Fairhurst et al. reported that saliva is responsible for moistening the mouth, providing oral hygiene, lubricating the bolus during swallowing, regulating esophageal acidity, destroying microorganisms, and facilitating flavor. Saliva control problems become pathological after the age of 4 (31). In our study, the effect of saliva on flavor facilitation was not investigated.

Senner et al. reported that swallowing disorder, cognitive impairment, sensory or functional impairment in oral structures, wrong posture of the head and neck, facial hypotonia, inadequate head control, low swallowing frequency, open mouth posture, continuation of primitive reflexes, and medications cause drooling problems (32). We also observed cognitive problems in patients with swallowing disorders.

Wright et al. showed that spasticity, limited movement, infection, and inadequate food intake cause problems with swallowing and feeding (33). Erkin et al. reported that digestive system problems are common in patients with CP because of nutrition and swallowing problems (16). In our study, infection and the digestive system were not evaluated.

Limitations

Our study faced several limitations that should be addressed in future research. First, the small sample size (n=20) limits the generalizability of our findings. While the results provide promising evidence for the effectiveness of TMJ mobilization in improving swallowing function, drooling control, and quality of life in CP patients, a larger sample size would increase statistical power and allow for subgroup analyses, such as comparisons across different CP types or severity levels.

Second, our exclusion of posture analysis and sensory evaluations highlights important areas for further exploration. As demonstrated by Manno et al., appropriate postural alignment plays a crucial role in facilitating swallowing, feeding, and speech processing. Future studies should incorporate posture evaluations to determine the interaction between postural alignment and TMJ dysfunction outcomes. Similarly, sensory evaluations could shed light on the sensory-motor integration processes that underpin TMJ mobilization's effects on functional outcomes. Including these factors would provide a more comprehensive understanding of the therapeutic mechanisms and improve the design of intervention programs.

Third, our study did not evaluate patients according to CP types, such as spastic, athetoid, or mixed types. Different CP types may present distinct patterns of TMJ dysfunction, drooling, and swallowing difficulties, which could influence treatment outcomes. Future research should stratify patients by CP type to tailor interventions more effectively and explore whether specific subgroups benefit more from TMJ mobilization.

The theoretical underpinnings of our study rest on the neuromuscular and biomechanical mechanisms associated with TMJ mobilization. By improving joint mobility and neuromuscular coordination, TMJ mobilization may enhance saliva control, facilitate better oral-motor function, and ultimately improve quality of life. This aligns with the principles of neuroplasticity, suggesting that targeted therapeutic interventions can induce functional reorganization in patients with neurodevelopmental disorders. Future studies should further investigate these mechanisms using advanced imaging or electrophysiological techniques to validate these theoretical frameworks.

Finally, ethical considerations were integral to our

study design. Informed consent was obtained from all participants' families, ensuring their voluntary participation. Confidentiality was maintained to protect personal data, and all interventions were conducted in a manner prioritizing patient safety and comfort.

CONCLUSION

As a result, it is observed that TMJ mobilization can increase the control of swallowing function, quality of life, passive mouth opening values, mandible protrusion values, and mandible lateral deviation values, and it can decrease drooling severity values in CP patients with TMD.

DECLARATIONS

Ethics Committee Approval: This study was carried out according to the ethical rules and principles of the Declaration of Helsinki. All participants were informed of the study protocol and provided informed consent, and patient data was retrospectively accessed and anonymized before analysis. The study protocol was approved by Istanbul Okan University Hospital's Ethics Committee (Date: 19.02.2018, IRB no: 91/22).

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AI: Not applied

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