Original papers

The influence of the structure of the masticatory system on the presence and severity of the gag reflex in children with cerebral palsy

Roksana Malak[1,A–D,F], Oskar Komisarek[2,A–D,F], Karolina Biel[1,B,F], Karolina Szuflak[3,4,B,F], Katarzyna Wiecheć[5,6,B,F], Tomasz Szczapa[7,B,C,F], Joanna Kasperkowicz[1,B,C,F], Maja Matthews-Kozanecka[8,B,F], Teresa Matthews-Brzozowska[2,C,E,F], Magdalena Kobylińska[9,B,F], Jacek Kwiatkowski[10,B–D,F], Włodzimierz Samborski[1,E,F], Ewa Mojs[5,C,F]

1 Department and Clinic of Rheumatology, Rehabilitation and Internal Medicine, Poznań University of Medical Sciences, Poland
2 Department of Otolaryngology, Audiology and Phoniatrics, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń, Poland
3 Department of Risk Group Dentistry, Chair of Pediatric Dentistry, Poznan University of Medical Sciences, Poland
4 Doctoral School, Poznań University of Medical Sciences, Poland
5 Department of Clinical Psychology, Poznań University of Medical Sciences, Poland
6 Department of Clinical and Health Psychology, SWPS University of Social Sciences and Humanities, Poznań, Poland
7 Neonatal Biophysical Monitoring and Cardiopulmonary Therapies Research Unit, 2nd Department of Neonatology, Poznań University of Medical Sciences, Poland
8 Department of Social Sciences and the Humanities, Poznań University of Medical Sciences, Poland
9 Department of Clinical Auxology and Pediatrics Nursing Faculty of Health Sciences, Poznań University of Medical Sciences, Poland
10 Students Scientific Society of Maxillofacial Orthopedics and Orthodontics, Poznań University of Medical Sciences, Poland

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;
D – writing the article; E – critical revision of the article; F – final approval of the article

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Address for correspondence
Jacek Kwiatkowski
E-mail: jacekkwiat@poczta.onet.pl

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Abstract

Background. Dysphagia, prevalent in 90% of children with neurological disorders, poses risks of medical complications and is associated with cognitive and psychosocial challenges. The absence of the sucking-swallowing reflex and variations in the gag reflex contribute to feeding difficulties.

Objectives. This study focuses on examining the impact of the gag reflex on the masticatory system structure in children with cerebral palsy, aiming to assess its significance.

Materials and methods. This observational study investigated the gag reflex and soft palate shape in 25 children with cerebral palsy (average age: 14 years). Inclusion criteria considered specific levels of the Eating and Drinking Ability Classification System (EDACS) and the Gross Motor Function Classification System (GMFCS). Exclusion criteria comprised hypotension, inflammation and tumors. The Castillo–Morales questionnaire assessed variables and statistical analysis (Spearman's rank correlation and non-parametric tests) utilizing PQStat v. 1.8.6.120 software.

Results. Findings did not reveal an association between the absence of the gag reflex and abnormal palate structure in children. Our results showed a correlation between higher tension of the buccinator muscles and mobility of the tongue on the structure of the palate.

Conclusions. Children with neurological disorders, such as cerebral palsy, are a diverse group requiring specialized orthodontic treatment and close interdisciplinary collaboration.

Key words: children, neurological disorders, gag reflex, masticatory system

Background

Dysphagia occurs in about 90% of children with neurological disorders.[1] Although feeding problems may lead to medical disorders such as malnutrition or gastroenterological dysfunction, some other aspects should also be taken into account. There are many research studies showing a connection between feeding difficulties and problems with cognitive skills, such as communication difficulties and psychosocial problems: lower self-esteem, social isolation and poor quality of life.[2–4] That is why specialists who take care of children with feeding problems should be aware of how the treatment of children with dysphagia is important for their patients and their surroundings. For instance, the Oxford Feeding Study showed strong correlations between the severity of motor delay and dysphagia.[5] It could be explained by the fact that disorders of the central nervous system may affect the frontal/insular–basal ganglia–brainstem swallowing pathway.[6] Therefore, children with dysphagia may have difficulty feeding due to the absence of the suck-swallow reflex or the absence of a gag reflex or hypersensitive reflex.[7] The diagnostic methods and therapy for the sucking reflex seem to be well known.[8] We think that the gag reflex should be explored and taken into account during the process of diagnosing and treating feeding difficulties in children.

The gag reflex, also known as the pharyngeal reflex, should be fully developed at about the 32nd week of gestation. The role of this reflex is to prevent swallowing foreign objects and the aspiration of a bolus into the respiratory tract.[9] The gag reflex is controlled by both the glossopharyngeal (IX) and vagus (X) nerves, in which the nerve roots exit the medulla through the jugular foramen and descend on both sides of the pharynx to innervate the posterior pharynx, posterior 1/3 of the tongue, soft palate, and the stylopharyngeus muscle.[9] In the first few months of life, the sucking reflex and gag reflex seem to be very strong. Starting around 6 months, the gag reflex diminishes but does not disappear completely, allowing infants to swallow more solid foods. Similarly, the sucking reflex is replaced by the function of the masticatory system.[10] Children with neurological disorders may have problems in eating because of problems with neurodevelopment in general, which can be a result of brain injuries during the perinatal period of life. This causes difficulties in neurodevelopmental skills and reflexes such as the suck-swallow and gag reflexes and with functions such as mastication and chewing. Sensorimotor dysfunction, as well as difficulties with maintaining the position of the trunk and head, may accompany dysphagia.[5–11] What is more, children with neurological diseases may suffer from gastrointestinal disorders leading to malnutrition and inadequate growth.[7]

Swallowing and speech use similar oral muscles and structures; therefore, it is possible that early patterns of eating impairment may impact speech and sound development.[12] That is why indirect problems with eating may lead to problems with cognitive skills.

Therefore, we think that reflexes that are involved in eating should be monitored as early as possible to improve not only safe feeding but also psychosocial skills.[13,14] Feeding problems may also lead to structural disorders such as temporomandibular joint dysfunction (TMD).[15,16] Abnormal oral reflexes and functions are correlated with hyperactivity of suprahyoid muscles.[17–19] Nowadays, the association between the suck-swallow reflex and the posture during eating seems to be satisfactory explored.[20,21]

Objectives

The purpose of this article was to analyze how the gag reflex influences the structure of the masticatory system in children with cerebral palsy. We hope that answering this question will allow the development of an easy and valid screening assessment and therapy regimen for children with feeding disorders.

Materials and methods

Study design

This observational study was approved by the Bioethics Committee (approval No. 481/21) on June 21, 2021. Informed consent was obtained from all subjects involved in the study.

Setting

The study was conducted in a controlled clinical setting.

Participants

We assessed 25 children with neurological diseases whose main diagnosis was cerebral palsy (16 girls and 9 boys with a median age of 11 years (range: 8–17 years)). The main inclusion criterion was the 5th (V) level in the Eating and Drinking Ability Classification System (EDACS). The EDACS enables the assessment of the functional capacity to eat and drink. There are 5 levels of the EDACS:

– Level I: eats and drinks safely and efficiently;

– Level II: eats and drinks safely but with some limitations to efficiency;

– Level III: eats and drinks with some limitations to safety;

– Level IV: eats and drinks with significant limitations to safety;

– Level V: unable to eat or drink safely. Tube feeding may be considered to provide nutrition.[22]

Others inclusion criteria were the presence of the suck reflex, the diagnosis of neurological disorders (cerebral palsy) and a 5th level of Gross Motor Function Classification System (GMFCS), which meant complete dependence on mobility, function and locomotion of the child. GMFCS I means that a child can walk, run and jump on their own; GMFCS II – that a child sometimes needs physical assistance; GMFCS III – that for long distances, children needed wheeled mobility and they also walk short distances with a hand-held mobility device; GMFCS IV – that physical assistance or powered mobility is required in almost all settings; and GMFCS V qualifiers require a wheelchair for mobility and have limited ability to control head and trunk positioning. Exclusion criteria in the present research study included hypotension, active inflammation and tumors.

Variables

The variables of interest in this study were the gag reflex and the shape of the soft palate. The gag reflex was checked by stimulating the posterior pharynx using a tongue blade when a child was in a semi-lying position. If a child produced a gagging reaction, we assessed it as 1 point, while when it was absent in the child, we gave 0 points. An orthodontist examined the shape of the soft palate and classified it as either narrow, typical or wide.

Data sources/measurement

We used the Castillo–Morales questionnaire to assess the gag reflex and soft palate. In compliance with ethical guidelines, all participants were thoroughly briefed about the study's purpose, procedures and potential risks. They had the opportunity to ask questions and could withdraw at any time. Prior to participating, each the parents or legal guardians of each participant provided their written informed consent, affirming their understanding and voluntary agreement to participate. All consent forms have been retained for verification purposes.

Study size

The study size was determined by the availability of participants who met the inclusion criteria.

Statistical analyses

Calculations were performed using PQStat v. 1.8.6.120 software (PQStat, Poznań, Poland). A significance level of $\alpha = 0.05$ was adopted. The result was considered statistically significant when $p < \alpha$. The normality of the age distribution was examined using the Shapiro–Wilk test. The relationship between variables was examined using Fisher's exact test or the Fisher–Freeman–Halton exact test with Bonferroni correction for multiple comparisons.

Results

We observed that children who did not have gag reflexes also did not have an abnormal structure to the palate. On the other hand, children who had a gag reflex had normal palates as well. There was no correlation between the gag reflex and the structure of the palate.

We also checked whether there was any correlation between the paralysis of the soft palate and the presence of a gag reflex. No correlations were noted.

Buccinator muscles are the muscular portion of the cheek responsible for helping compress the cheek against the teeth during actions such as chewing and blowing – cheek muscles are involved with the shape of the palate ($p = 0.015$, Table 1). If the tone of the buccinator muscles was higher, then a narrow palate was more often observed ($p = 0.015$) or even a gothic palate was seen ($p = 0.017$, Table 2,3). The palatal folds were observed more

Table 1. Fisher's exact test for association between the tension of the cheek muscles and the structure of the palate

Tension of the cheek muscles	Summary 2-way table: Observed frequencies		
	Palate structure: Normal? 1. Yes	Palate structure: Normal? 2. No	Total row
1. Increased	0	7	7
2. Normal	8	5	13
Total	8	12	20

Fisher's exact test $p = 0.015$ – there is an association. A statistically significant association with $p < 0.05$ was noted between the tension of the cheek muscles and the structure of the palate. In cases of increased tension in the cheek muscles, abnormal palate structure was more common.

Table 2. Fisher's exact test for association between the tension of the cheek muscles and the presence of a narrow palate

Tension of the cheek muscles	Summary 2-way table: Observed frequencies		
	Palate structure: Narrow? 1. Yes	Palate structure: Narrow? 2. No	Total row
1. Increased	7	0	7
2. Normal	5	8	13
Total	12	8	20

Fisher's exact test $p = 0.015$ – there is an association. A statistically significant association with $p < 0.05$ was noted between the tension of the cheek muscles and the presence of a narrow palate. Increased tension in the cheek muscles was associated with a narrow palate.

Table 3. Fisher's exact test for association between the tension of the cheek muscles and the presence of a gothic palate

Tension of the cheek muscles	Summary 2-way table: Observed frequencies		
	Palate structure: Gothic? 1. Yes	Palate structure: Gothic? 2. No	Total row
1. Increased	6	1	7
2. Normal	3	10	13
Total	9	11	20

A statistically significant association with $p < 0.05$ was noted between the tension of the cheek muscles and the presence of a gothic palate. Increased muscle tension was associated with the presence of a gothic palate.

Table 4. Fisher's exact test for association between tongue muscle mobility and the presence of very distinct palate folds

Tongue muscles: Tongue mobility	Summary 2-way table: Observed frequencies		
	Are palate folds very distinct? 1. Yes	Are palate folds very distinct? 2. No	Total row
1. Abnormal	0	5	5
2. Normal	11	4	15
Total	11	9	20

Fisher's exact test $p = 0.008$, there is an association. A statistically significant association with $p < 0.05$ was noted between tongue muscle mobility and the presence of very distinct palate folds. The presence of pronounced palate folds was more common in individuals with impaired tongue muscle function.

often in children with abnormal tongue muscle mobility ($p = 0.008$, Table 4). We also examined the rotator and flexor muscles of the head and neck, and noted that sternocleidomastoid muscles (SCM) were involved with the shape of the palate ($p = 0.031$, Table 5,6). If the tone of the SCM was higher, then a narrow palate was more often observed ($p = 0.031$, Table 7,8). The palatal folds were observed more often in children with hypertonic SCM ($p = 0.046$, Table 9,10). However, statistical tests involving the SCM were unable to determine any differing groups.

Discussion

Brainstem control is pivotal in orchestrating the complex mechanisms of the gag reflex. Centered in the medulla oblongata, the nucleus tractus solitarius (NTS) assumes a central role, receiving sensory input from the oropharynx via the glossopharyngeal (cranial nerve IX) and vagus nerves (cranial nerve X). Afferent fibers convey touch, pressure and taste sensations, crucial for triggering the gag reflex. The trigeminal (cranial nerve V) and facial nerves (cranial nerve VII) may also contribute to sensory modulation. The efferent fibers from the glossopharyngeal and vagus nerves relay signals to the muscles involved in the reflex, while the hypoglossal nerve (cranial nerve XII) aids in coordinating motor responses. The NTS acts as an integrating center for sensory information, not only from the oropharynx but also from visceral organs, influencing

Table 5. Fisher–Freeman–Halton exact test for association between rotator and flexor muscles of the head and neck and palate structure

Rotator and flexor muscles of the head and neck	Summary 2-way table: observed frequencies		
	Palate structure – normal? 1. Yes	Palate structure – normal? 2. No	Total row
1. Asymmetrically increased	6	7	13
2. Symmetrically increased	2	0	2
3. Normal	0	5	5
Total	8	12	20

Fisher–Freeman–Halton exact test $p = 0.031$, there is an association.

Table 6. Bonferroni multiple comparison for association between rotator and flexor muscles of the head and neck and palate structure

Rotator and flexor muscles of the head and neck	Bonferroni multiple comparison: p-value, χ2/*Fisher (Cochran's nonspecific)		
	3. Normal	2. Symmetrically increased	1. Asymmetrically increased
1. Asymmetrically increased	0.342437*	1*	–
2. Symmetrically increased	0.142857*	–	1*
3. Normal	–	0.142857*	0.342437*

Since Table 5 presents the Fisher–Freeman–Halton exact test indicating an association between the rotator and flexor muscles of the head and neck and the palate structure ($p = 0.031$), it was necessary to identify which groups differed. However, after applying the Bonferroni multiple comparison method, it was not possible to determine specific group differences.

Table 7. Fisher–Freeman–Halton exact test for association between rotator and flexor muscles of the head and neck and palate shape

Rotator and flexor muscles of the head and neck	Summary 2-way table: Observed frequencies		
	Palate structure: Normal? 1. Yes	Palate structure: Normal? 2. No	Total row
1. Asymmetrically increased	7	6	13
2. Symmetrically increased	0	2	2
3. Normal	5	0	5
Total	12	8	20

Fisher–Freeman–Halton exact test $p = 0.031$, there is an association.

Table 8. Bonferroni multiple comparison for association between rotator and flexor muscles of the head and neck and palate shape

Rotator and flexor muscles of the head and neck	Bonferroni multiple comparison: p-value, χ2/*Fisher (Cochran's nonspecific)		
	3. Normal	2. Symmetrically increased	1. Asymmetrically increased
1. Asymmetrically increased	0.342437*	1*	–
2. Symmetrically increased	0.142857*	–	1*
3. Normal	–	0.142857*	0.342437*

Since Table 7 presents the Fisher–Freeman–Halton exact test indicating an association between rotator and flexor muscles of the head and neck and palate shape (p = 0.031), it was necessary to identify which groups differed. However, after applying the Bonferroni multiple comparison method, it was not possible to determine specific group differences.

Table 9. Fisher–Freeman–Halton exact test for association between rotator and flexor muscles of the head and neck and palate folds

Rotator and flexor muscles of the head and neck	Summary 2-way table: Observed frequencies		
	Are palate folds very distinct? 1. Yes	Are palate folds very distinct? 2. No	Total row
1. Asymmetrically increased	5	8	13
2. Symmetrically increased	1	1	2
3. Normal	5	0	5
Total	11	9	20

Fisher–Freeman–Halton exact test p = 0.046, there is an association.

Table 10. Bonferroni multiple comparison for association between rotator and flexor muscles of the head and neck and palate folds

Rotator and flexor muscles of the head and neck	Bonferroni multiple comparison: p-value, χ2/*Fisher (Cochran's nonspecific)		
	3. Normal	2. Symmetrically increased	1. Asymmetrically increased
1. Asymmetrically increased	0.107843*	1*	–
2. Symmetrically increased	0.857143*	–	1*
3. Normal	–	0.857143*	0.107843*

Since Table 9 presents the Fisher–Freeman–Halton exact test indicating an association between rotator and flexor muscles of the head and neck and palate folds (p = 0.046), it was necessary to identify which groups differed. However, after applying the Bonferroni multiple comparison method, it was not possible to determine specific group differences.

reflex modulation. Beyond the brainstem, higher brain regions, particularly the cerebral cortex, exert influence on emotional and cognitive factors impacting the reflex. Neurotransmitters like serotonin, GABA and glutamate play a role in modulating the gag reflex by influencing neuronal excitability. Neural plasticity in the central nervous system contributes to the adaptation or impairment of the reflex over time, with changes in synaptic strength influenced by experiences, trauma or neurological disorders.[23–26] Understanding these intricate neural pathways not only sheds light on variations in the gag reflex but also enhances the comprehension of feeding challenges and clinical implications like dysphagia in neurological disorders.

Brainstem lesions and associated neurological disorders can lead to dysfunction of the gag reflex. Damage to the NTS or the glossopharyngeal and vagus nerves, commonly seen in brainstem lesions, may result in either an impaired or hyperactive gag reflex. Beyond the brainstem, dysregulation of broader neural networks, including the cerebellum and basal ganglia, can disrupt the coordination of motor responses during the gag reflex, contributing to feeding difficulties. Imbalances in neurotransmitter systems, such as serotonin and GABA, further complicate the scenario, impacting neural activity in the brainstem and associated areas. Considering developmental aspects, children with neurological disorders face challenges as their nervous systems are still maturing, potentially influencing the establishment of normal feeding behaviors. Additionally, higher brain regions involved in cognitive and emotional processing may exacerbate or modulate the gag reflex in the context of neurological disorders.

The muscles of the head and neck are involved in structural and functional development of the masticatory system and primarily with reflexes of this system. We presented for the first time a study that showed that hypertonic SCM (cranial nerve XI) is related to the abnormal shape of the palate in children with cerebral palsy. Similar correlations were found between temporal (cranial nerve V) and buccinator muscles (cranial nerve VII).[27] The gag reflex involves bilateral pharyngeal muscle contractions and elevation of the soft palate.[9] That is why reflexes such as sucking, swallowing and gagging may be responsible for the shape of the palate. If the reflexes are retained then the lack of pressure may affect the structure of the palate.[28] During the initiation time of oral functions to full oral feeding, various internal and external factors influence palatal development and lead to a higher risk for facial abnormalities and other orthodontic consequences. Children who have cerebral palsy may have disorders in the shape of the palate because of intubation and positioning. For instance, children who were not intubated have a lower palatal depth compared to intubated children.[29]

Recognizing the variability in the nature and extent of neurological deficits among affected children is crucial for tailoring interventions and management strategies. Targeted rehabilitative approaches, encompassing physical therapy, sensory integration strategies and interventions focused on neural plasticity, offer promise in improving the gag reflex and overall feeding abilities.[30–32] A multidisciplinary collaboration involving neurologists, speech therapists, occupational therapists, and nutritionists is indispensable for addressing the multifaceted nature of neurological deficits impacting the gag reflex. By delving into the intricate connections between neurological deficits and the gag reflex, researchers and clinicians can develop nuanced strategies for the assessment and management of feeding difficulties in children with neurological disorders, ultimately enhancing the quality of life for both the affected child and their families.

Children with neurological diseases may not present a gag reflex upon stimulation.[7,33] On the other hand, gagging during feeding in early childhood is one risk factor for developing dysphagia.[34] There is a study that showed that the specificity of the gag reflex in detecting dysphagia was 96%, with a sensitivity of 39%. The presence of the gag reflex means that a person has protection against long-term swallowing problems.[35] That is why the gag reflex is called a protective reflex. One of the functions of the gag reflex is to prevent swallowing foreign objects and prevent choking or aspiration.[9] That is why patients with severe cerebral palsy who do not have a gag reflex may suffer from aspiration pneumonia as a major complication, which is dangerous because of its association with their survival prognosis.[36] Gagging is sometimes called a vital reflex because its role is to stop unwanted bolus entry into the oropharynx, which helps in avoiding aspiration of food into the airways since may lead to death.[37] It is sometimes called a "must part" of the assessment of brainstem function.[35] The gag reflex, which is the most easily and commonly tested airway reflex and the absence of which is recognized as one of the criteria for brainstem death, should be a part of the typical assessment of children with feeding difficulties. Neurons controlling gagging or vomiting are associated with nuclei within the brainstem controlling vasomotor, respiratory, salivary, vestibular, and cardiac activity.[38] The afferents of the gag reflex go to the medulla oblongata. That is why the heart rate may be indirectly influenced by the gag reflex.[39] A normal gag reflex is controlled mainly by the parasympathetic division of the autonomic nervous system. Children with cerebral palsy may present higher activity of the sympathetic nervous system and higher vasomotor tonicity resulting from lesions in specific brain sites that can cause peripheral blood vessel vasoconstriction and constrain cutaneous blood flow. This is because contracting muscles need to be able to increase their blood flow.[40] Although the gag reflex is governed mostly by the parasympathetic nervous system, both parasympathetic and sympathetic activations are observed during the stimulation of the gag reflex.[41] Therefore, some children with cerebral palsy have absent gag reflex, while others have a pronounced one.[37] Certainly, further studies are needed to describe the relationship between the occurrence of the gag reflex and the activation of the autonomic nervous system in children with neurological disorders.

The muscles of the head and neck are involved in structural and functional development of the masticatory system and primarily with reflexes of this system. It is the first study to show that hypertonic SCM is associated with the abnormal shape of the palate in children with cerebral palsy. Similar correlations were found with the temporal and buccinator muscles. The gag reflex involves bilateral pharyngeal muscle contraction and elevation of the soft palate.[9] That is why reflexes such as sucking, swallowing and gagging may be responsible for the shape of the palate. If the reflexes are retained, then the lack of pressure may influence the structure of the palate.[28] During the time of oral function initiation to full oral feeding, various internal and external factors influences may affect palatal development and lead to a higher risk for facial abnormalities and other orthodontic consequences. Children who have cerebral palsy may have disorders in the shape of the palate because of intubation or positioning. For instance, children who were not intubated revealed a lower palatal depth compared to intubated children.[29] Our observations indicated that the gag reflex may also influence the shape of the palate, in a manner analogous to the findings of Asdaghi Mamaghani et al., who demonstrated that patients with cerebral palsy exhibited an abnormal flattening of the palatal arch.[28] Abnormalities in palate formation in children may have serious functional and cognitive consequences in terms of speech, mastication, the mode of breathing, swallowing, and Eustachian tube function. The most fragile months in the growth of the palate are from birth up to 3 months when the sagittal direction changes the most and the round arch changes into oval arch forms.[42] This is the rationale behind the previous studies, which demonstrated the necessity of examining neurobehavioral disorders, including the gag reflex in neonates or children aged 3 months, in order to provide the most appropriate therapy, which can help children to eat (when fed orally) without any problems.[43,44]

The gag reflex may be evoked by stimulation of the posterior pharyngeal wall, tonsillar area or the base of the tongue. It is an essential component of evaluating the medullary brainstem and plays a role in the declaration of brain death.[9,43,44]

Gagging is responsible not only for the structure but also for the function of such structures as the tongue, hyoid bone and soft palate. Glossopharyngeal and vagus nerves control the gag reflex as well as innervate the soft palate. We showed that children who did not have a gag reflex also had paresis of the soft palate. Normally, intraoral stimulation of the gag reflex is connected with the afferent reaction of fibers from the trigeminal, glossopharyngeal and vagus nerves, which report to the medulla oblongata.[45] The neural control of the soft palate is similar. Both the glossopharyngeal (IX) and vagus (X) nerves contribute to the innervation of the palatoglossus and palatopharyngeus.[46] The functions of the soft palate depend on reflexes mediated by sensory nerve endings. The soft palate is also engaged in such motor activities as respiration, swallowing and speech.[47] This relationship shows the importance of functions or reflexes on the structure of the soft palate and vice versa. The orofacial complex comprises the oral cavity organs as well as the facial part – muscles of the masticatory system and the motor coordination areas of the nervous system.[48] The gag reflex is regarded as a part of neurocognitive behaviors. An abnormal gag reflex, together with abnormal volitional cough, dysphonia, dysarthria, coughing after swallowing, and voice changes after swallowing, are known as clinical features of the risk of aspiration. The gag reflex is one of the clinical and cognitive predictors of swallowing recovery in patients with brain injuries.[49] The gag reflex may be initiated by either somatic stimuli (i.e., sensory nerve stimulation from direct contact) or psychogenic stimuli (i.e., by higher centers in the central nervous system). Not only typical physical stimuli such as tactile stimulation of the oropharynx by placing an object next to the uvula, the posterior pharyngeal wall, the tonsillar area or on the base of the tongue may evoke the gag reflex, but also such psychological factors as fear, stress or phobia can trigger gagging. As a result, efferent impulses give rise to spasmodic and uncoordinated muscle movement. This results in the center in the medulla oblongata being activated during gagging. That is why the management strategies for optimizing the gag reflex may be different – both conventional and complementary, such as behavioral techniques, pharmacological techniques and complementary therapies.[50] Future studies should be developed to describe the treatment of hyper and hyporeflexia of the gag reflex. This study aimed to show how important the gag reflex is as a vital reflex as well as a reaction that has influences on the structure and psychomotor function. One of the psychomotor and cognitive aspects which is associated with the gag reflex is communication. Therefore, all professionals working with children with developmental disabilities should know how to check the gag reflex.

What is more, because of the period of dominating reflexes lasts from birth to approx. 6–7 months, early intervention, examination and therapy seem to be very important, especially in the first months of life.[10] This is why it is important to examine the orofacial region, including the gag reflex, during the child's development.

The management of feeding dysfunction in children with neurological disorders should be complex and requires well-coordinated multidisciplinary teams who clearly communicate with families.[33]

Limitations

The limitation was that only 25 children with neurological diseases were evaluated and the main diagnosis was cerebral palsy. Although the condition is rare, future studies should consider increasing the number of study participants to make the results more representative.

Conclusions

Children with neurological disorders, such as cerebral palsy, are a very heterogeneous group that requires special orthodontic treatment as well as close interdisciplinary cooperation.[38] Proper complex care of children with neurological diseases is possible only if they are properly examined. One of the elements of this examination should be checking the gag reflex.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

ORCID iDs

Roksana Malak https://orcid.org/0000-0003-0521-5249
Oskar Komisarek https://orcid.org/0000-0002-1037-3711
Karolina Biel https://orcid.org/0009-0008-6363-7478
Karolina Szuflak https://orcid.org/0000-0002-0043-1674
Katarzyna Wiecheć https://orcid.org/0000-0003-4013-0443
Tomasz Szczapa https://orcid.org/0000-0002-5214-2719
Joanna Kasperkowicz https://orcid.org/0000-0003-3959-7214
Maja Matthews-Kozanecka https://orcid.org/0000-0002-3437-6263
Teresa Matthews-Brzozowska https://orcid.org/0000-0002-7127-6018
Magdalena Kobylińska https://orcid.org/0000-0002-3871-2412
Jacek Kwiatkowski https://orcid.org/0000-0002-2434-4313
Włodzimierz Samborski https://orcid.org/0000-0002-0338-894X
Ewa Mojs https://orcid.org/0000-0002-4651-9444

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