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Original Article

Occurrence of Dental Anomalies in Children with Cerebral Palsy: A Comprehensive Analysis

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ABSTRACT

Children diagnosed with CP face an increased likelihood of compromised dental and overall health due to their condition. Several factors contribute to the development of caries, including past and current caries history, dietary habits, fluoride intake, presence of cariogenic bacteria, salivary characteristics, and sociodemographic influences. Additional risk factors include prolonged use of oral medications that induce xerostomia, difficulties with oral motor function, and inadequate oral hygiene practices. This study aimed to consolidate primary data to gain a clearer understanding of the key risk factors associated with the high prevalence of caries in this vulnerable population. A systematic review of the literature published between 2009 and 2022 was conducted using databases such as PubMed, Science Direct, and Medline. The search incorporated the keywords “cerebral palsy,” “dental defects,” “pediatric patients,” and “systematic review.” Article selection was illustrated using the PRISMA flowchart. A total of 9 studies were analyzed, with six indicating no notable differences in the opacity, color, and fluorescence of composite restorations. Findings from further studies highlighted a high prevalence of dental defects, including periodontal disease, caries, and erosion, among pediatric patients with cerebral palsy.

Keywords: Systematic review, Composite resins, Hydrogen peroxide, Bleaching

Introduction

Cerebral palsy (CP) is a lifelong neurodevelopmental condition resulting from brain damage during infancy. Children affected by CP face an elevated risk of compromised dental and overall health due to their physical limitations. The condition is classified into quadriplegia, diplegia, and hemiplegia, which correspond to different patterns of motor dysfunction. Based on the extent of neurological impairment, CP is further categorized into spastic, dyskinetic, ataxic, and mixed forms. These motor challenges contribute to lifelong difficulties in self-care, including oral hygiene maintenance. Several factors influence caries development, including previous and current caries experience, dietary intake, fluoride exposure, cariogenic bacterial presence, salivary composition, and sociodemographic factors. Additional contributors to oral health issues include prolonged use of xerostomia-inducing medications, impaired oral motor function, and inadequate daily oral care [1-4].

Dental caries poses a major challenge for children with CP, with studies indicating that their oral health is generally poorer compared to those without CP. This leads to a higher number of tooth extractions, suboptimal restorations of decayed teeth, and overall inadequate oral hygiene. Several factors may contribute to the increased prevalence of caries, including neuromuscular disorders, structural abnormalities in the orofacial region, feeding difficulties, difficulties with oral hygiene maintenance, and limited access to dental services. De Carvalho *et al.*

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[5] reported that in 73.1% of cases, oral hygiene was supervised by caregivers due to impaired manual dexterity, resulting in no significant correlation between CP type and tooth brushing frequency. These results align with the findings of Camargo and Antunes. The severity of neurological impairment directly impacts oral health, as evidenced by individuals with quadriplegia having a mean decayed-missing-filled (DMF) score twice as high as those with hemiplegia. Limited access to dental care and challenges in maintaining effective oral hygiene highlight the need for targeted interventions to improve oral health outcomes. A child's oral health-related quality of life is influenced by the extent of dental caries, communication ability, and family socioeconomic status [6]. Although studies indicate a higher incidence of caries in this population, few have comprehensively examined the full spectrum of risk factors affecting specific subgroups of CP patients. Potential contributors identified include socioeconomic background, CP classification, demographic characteristics, oral health status, hygiene routines, and dietary habits [7].

To deliver effective oral health education to adolescents and children with CP, it is essential to first identify the factors responsible for their elevated risk of dental caries. This study aims to consolidate primary data to gain a clearer understanding of the key risk factors associated with the high prevalence of caries in this vulnerable population. Several studies serve as the foundation for developing this future systematic review, evaluating the scope of existing research, and identifying potential gaps in knowledge. The findings of this study categorize previously recognized risk factors into specific domains, providing a framework for further research exploration [8].

Materials and Methods

A comprehensive review of the literature from 2012 to 2022 was conducted utilizing the PubMed, Science Direct, and Medline, databases. The search was performed using the keywords, "dental defects," "systematic review", "pediatric patients," and "cerebral palsy," **(Table 1)**. The PRISMA flowchart was employed to illustrate the article selection process **(Figure 1)**.

Table 1. Criteria for exclusion and inclusion

№	Inclusion criteria	Exclusion criteria
1.	Case-control and randomized control studies	Systematic reviews, meta-analyses, expert opinions, or narrative reviews
2.	Published between 2009 and 2022	Out of the specified time range
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

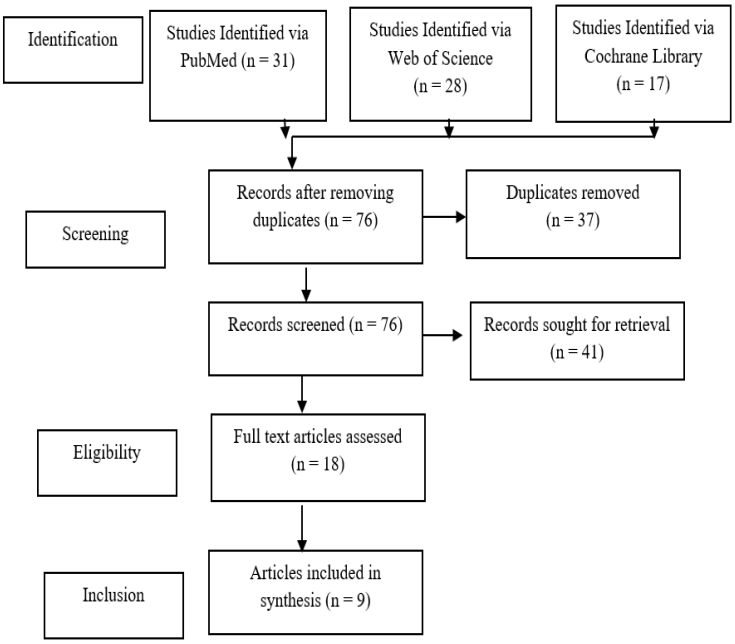

Figure 1. PRISMA flow diagram

Risk of bias assessment

The quality of the included studies was evaluated using the Cochrane risk of bias assessment method **(Table 2)**.

Table 2. Overview of Cochrane risk of bias assessment.

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias
Du *et al*. [9]	+	+	+	+	+	+	-
Cardoso *et al*. [10]	+	+	+	+	-	+	-
Gržić *et al*. [11]	+	+	+	+	+	_	+
Polat *et al*. [12]	+	+	+	+	+	+	-
Santos *et al*. [6]	+	-	+	+	+	+	+
Lin *et al*. [13]	+	+	+	-	+	+	+
Al Hashmi *et al*. [14]	+	+	+	+	+	+	-
Santos *et al*. [15]	+	-	+	+	+	+	+
Dias *et al*. [16]	+	+	-	+	+	+	+

Results and Discussion

The research by Du *et al*. [9] aimed to assess the oral health of preschool children with and without CP. A total of 72 preschoolers, aged approximately 3 months, with CP, were selected. Among every one hundred children with CP, 42.5 exhibited dental caries (dmfs > 0), with a mean fs of 0.45. The rate of dental caries was similar between children with and without CP ($P > 0.05$). For the index teeth, the average plaque index score for children with CP was 0.89, while the mean gingival index score was 0.81. Children with CP had significantly higher scores on both the plaque index ($P < 0.001$) and the gingival index ($P = 0.02$) compared to those without CP. Gingival hyperplasia was observed in 19.2% (14/72) of CP-affected children, whereas no signs of gingival hyperplasia were found in children without CP.

Cardoso *et al*. [10] conducted a study to examine the prevalence of periodontal disease and dental caries among Brazilian children and adolescents with CP and the associated risk factors. Eighty patients, aged 2-18 years, participated in this cross-sectional study. The mean gingival bleeding index was 22.44%, and in the community periodontal index, the prevalence of gingival bleeding, calculus, shallow and deep pockets were 94.73%, 79.62%, 12.90%, and 3.22%, respectively. Dental caries were more common in children whose caregivers had less than 8 years of schooling. Negative correlations were found between periodontal changes and being female, having a caregiver with less education, poor oral health perception, severe communication difficulties, and the athetoid form of CP. High rates of periodontal disease and dental caries were observed among CP patients, with these findings linked to their epidemiological, social, economic, and dental health status, as well as systemic conditions.

Gržić *et al*. [11] conducted a study comparing the oral health of children with and without CP. The study initially recruited 50 children with CP from organizations supporting children with disabilities, ultimately examining 43 children aged 7-16 years. The findings revealed a significant difference in the number of filled teeth between typically developing children and those with CP. Children with CP were more likely to require extractions compared to their peers. However, there was no significant difference in the number of decayed teeth between the 2 groups, as indicated by the DMFT index. This suggests that many children in both groups did not receive sufficient restorative care, as decayed teeth were more prevalent than those that were extracted or filled. The study concluded that to reduce the incidence of cavities and improve oral health in this high-risk population, earlier intervention and better organization of preventive dental and pediatric care are needed.

Polat *et al*. [12] aimed to explore the relationship between gastroesophageal reflux disease (GERD) and dental erosion (DE) in children with CP. The study included 37 children with CP (nineteen boys, eighteen girls; mean age 12.1 ± 2.8 years), of whom 21 had DE and 16 did not. The results showed a significant difference in the distribution of interference ratios between multi-surfaced DE and non-multi-surfaced DE ($P < 0.001$). Multi-surfaced erosion affected 93.6% of the teeth, with 58.9% showing damage, while a much lower percentage of teeth had damage limited to 1 or 2 surfaces. Participants with DE were further categorized based on tissue loss into dentin-positive (dentin+) and dentin-negative (dentin-) groups. The interference ratios for dentin+ samples differed significantly from those of the dentin group ($P = 0.025$).

Santos *et al*. [6] investigated the connection between gastroesophageal reflux and DE in individuals with CP. A total of 108 participants (four females and 58 males) aged 4 to 19 years were included in the study to assess the relationship between motor impairments, caries experience, and dietary consistency. The overall DMF mean values (with standard deviations) were compared among the 4 categories of OFMFAS in CP patients, and each category was analyzed individually. No significant differences were found when comparing the overall DMF index or the individual D, M, and F values across the four OFMFAS categories ($P > 0.311$, 0.097, 0.292, and 0.090, respectively). Subjects with moderate to severe impairment showed higher total DMF scores than those with mild or minimal impairment, though this difference wasn't important statistically ($P = 0.063$).

Lin *et al*. [13] analyzed the prevalence and distribution of developmental enamel defects among children with CP in Beijing, China. The study included 135 children aged eighteen months to 6 years, all diagnosed with moderate to severe congenital CP. Of these, 44 children (32.6%) exhibited some form of enamel abnormality, including opacity and hypoplasia. Specifically, 35 children (24.9%) had enamel hypoplasia, 5 children (3.7%) had opacity alone, and 4 children (3.0%) had combined abnormalities. Enamel defects were most commonly found in the primary incisors and first molars. Premature birth was identified as a risk factor for enamel abnormalities in 42.4% of the affected children ($P < 0.05$).

The study by Al Hashmi *et al*. [14] aimed to assess the oral health conditions of children with CP in Dubai, UAE. A total of 84 children with CP and one hundred twenty-five healthy children aged 4-18 years were selected from special needs centers and both private and public schools in Dubai. The overall mean DMFT and dmft scores were found to be similar between the two groups. However, children with CP exhibited a significantly higher risk of having carious lesions. Additionally, CP children presented a greater frequency of oral health issues, including DE, macroglossia, angular cheilitis, lymphadenopathy, high arched palate, trauma, drooling, tongue thrusting, anterior spacing, anterior open bite, and Class II molar Angle malocclusion, compared to the control group.

Santos *et al*. [15] explored the influence of salivary osmolality on gingivitis among children with spastic CP. The study, which involved 82 children aged 6-14 years, found a significant association between gingivitis and factors such as salivary flow rate, salivary osmolality, clinical plaque index, and dental calculus. The correlation coefficient ($r > 0.7$) indicated a strong relationship between these variables. The predictive value of salivary osmolality for gingivitis was 0.88 ($P < 0.001$). A threshold of 84.5 for salivary osmolality demonstrated sensitivity and specificity of more than 77%. When salivary osmolality exceeded 84.5, the likelihood of gingivitis increased fivefold. Conversely, an increase of 0.1 milliliters in salivary flow was linked to a 97% reduction in the risk of developing gingivitis.

In a study by Dias *et al*. [16], the topic of sialorrhea in children with CP was examined. Speech therapy, which aims to enhance the patient's oral motor skills and sensory awareness, was identified as the most effective approach for managing sialorrhea in CP children. For cases of moderate to severe respiratory complications or sialorrhea, botulinum toxin injections, and anticholinergic medications may be considered supplementary treatments to speech therapy because of their temporary effects. Atropine sulfate, known for its affordability, good clinical response, and safety profile, is commonly used in treatment. Trihexyphenidyl may also be considered in cases involving dyskinetic CP or other specific conditions **(Table 3)**.

Table 3. Overview of results from the studies included

Author's name	Patients	Age	Objective	Dental defects	Results
Du *et al*. [9]	72	± 3 months	The objective of this study was to assess the oral health of preschool-aged children both with and without CP.	Dental caries, Gingival hyperplasia	Children with CP had higher scores on both the plaque index ($P < 0.001$) and the gingival index ($P = 0.02$) compared to those without CP.

Cardoso *et al*. [10]	80	2-18 years	The goal of this study was to assess the prevalence of dental caries and periodontal disease among Brazilian children and adolescents with CP.	Dental caries and periodontal changes	CP patients exhibited a significantly higher incidence of dental caries and periodontal issues.
Gržić *et al*. [11]	50	7-16 years	The objective of this study was to assess and compare the oral health and dental conditions of children with and without CP.	Tooth decay	The DMFT index includes the number of decayed teeth, and no significant statistical difference was observed between the two groups.
Polat *et al*. [12]	37	2-12 years	This study aimed to explore the link between DE and gastroesophageal reflux disease (GERD) in individuals with CP.	DE	It was observed that multi-surface erosion occurred in 58.9% or fewer of the affected teeth, affecting 93.6% of the impacted teeth.
Santos *et al*. [6]	108	2-19 years	The aim was to assess the link between DE and gastroesophageal reflux in individuals with CP.	DE, dental caries	The difference did not reach statistical significance (P = 0.063).
Lin *et al*. [13]	135	18 months-6 years	The objective of this study was to investigate the occurrence and distribution of enamel development abnormalities in children with CP.	Opacity and hypoplasia	Among the 135 children with CP, 44 (32.6%) exhibited some form of enamel abnormality.
Al Hashmi *et al*. [14]	84	4-18 years	This study aimed to assess the oral health condition of children with CP in Dubai.	Anterior open bite, anterior spacing, Class II molar Angle malocclusion, trauma, high arched palate	Children with CP exhibited a significantly higher risk of having CI.
Santos *et al*. [15]	82	6-14 years	Examine the impact of salivary osmolality on gingivitis in children with CP.	Gingivitis	The salivary osmolality had a predictive value of 0.88 for the occurrence of gingivitis (P<0.001).
Dias *et al*. [16]			To examine the studies conducted on sialorrhea in children with CP.	Sialorrhea	Speech therapy aims to enhance the patient's sensory perception and oral motor skills.

Children with CP exhibit similar rates of dental caries to their typically developing counterparts but demonstrate poorer periodontal health, a key indicator of oral well-being. The consensus on whether children with CP are more or less susceptible to caries remains unclear. Nonetheless, various studies suggest that children with CP either face the same or lower risk of developing cavities. In contrast, these children tend to have significantly worse gingival health than their peers in regular preschools, as corroborated by other research [17]. The challenge of maintaining proper dental hygiene, particularly among older children, may be exacerbated by a lack of neuromuscular control. Additionally, the use of anticonvulsant medications, known to cause gingival hyperplasia, may play a role in the increased occurrence of this condition in children with CP [18].

The occurrence of dental caries in children with CP was found to be higher compared to studies involving children without neurological impairments. Factors such as involuntary movements, abnormal oral reflexes, food retention, and spasticity in masticatory muscles are believed to contribute to the increased rates of caries in those with CP [19].

Children with CP exhibited a median DMFT score of 18.5, while those without CP had a median score of 16, with both groups showing a median DFT value of 0. Both groups demonstrated comparable rates of tooth decay. In a study by De Camargo *et al*. [17], the CP group had a lower prevalence of caries than the typically developing population. On the other hand, Al-Mendalawi reported similar caries rates, while Guaré and Santos observed a higher prevalence. Since no significant difference was found in the rates of tooth decay between the 2 groups in

our study, we concluded that children in institutional settings may require more thorough care compared to healthy children living at home with their families [20].

Tooth erosion in children with CP has been associated with various eating difficulties, including irritability, vomiting, choking, and chest infections. DE can affect both primary and permanent teeth, with early signs of gastroesophageal reflux disease (GERD) often manifesting as enamel wear on the molars. A study by Grzić *et al*. examined gastroesophageal reflux disease and DE in children with both primary and permanent teeth, finding that erosion was more prevalent in the posterior teeth [11].

The decay observed in our sample aligns with results from previous research. Our study recorded a DMF score of 5.56 for adult teeth, similar to prior studies. The total DMF score of 8.92, with a filled component of 0.92, was highest in the oldest age group (over 16), which had a score of 6.07. Massoni *et al*. understood that the total DMF score increased with age, but with a lower filled component [21].

When comparing children with CP to healthy controls of all ages, no significant differences were found in caries experience based on the DMFT/dmft index. However, a study from Sharjah, UAE, found that CP children had a significantly higher DMFT. Additionally, in both mixed and permanent dentition, the MNI and RI of CP children were lower compared to healthy controls, underscoring the importance of dental care for this population. Interestingly, CP children showed a higher MNI in their primary teeth compared to non-CP children. Sinha's research indicated that 82% of children with CP had dental defects [7].

Plaque accumulation on teeth is widely recognized as a cause of gum disease and cavities, but the difficulty in ensuring proper dental hygiene for children with CP is also an important factor. Several elements impact both biofilm control and toothbrushing, including motor and cognitive impairments, pathological oral reflexes such as vomiting and biting, the child's posture during oral care, and changes in intraoral sensitivity [22].

Swallowing saliva relies on an intact swallowing reflex, a coordinated function involving the mandible, lips, pharynx, tongue, esophagus, and larynx, all governed by orofacial neuromuscular systems. Children with CP often face challenges like difficulty forming a food bolus, inadequate lip sealing, suction issues, excess food residue, and difficulty coordinating the tongue, lips, and jaw, all of which contribute to an increased risk of sialorrhea. Additional factors such as reduced intraoral sensitivity, infrequent spontaneous swallowing, dysphagia during the esophageal phase, and malocclusion also exacerbate the condition. Sialorrhea is closely linked to a diminished ability to chew and swallow effectively. Its prevalence and severity are further influenced by other common characteristics in children with CP, such as an open mouth posture, poor body positioning (particularly of the head), intellectual impairments, emotional state, and attention levels [23].

Conclusion

Children with CP frequently experience dental issues, including periodontal disease, caries, and erosion.

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