Prevalence of Dental Malocclusion Among Patients with Cerebral Palsy in Riyadh, Saudi Arabia: A Cross-Sectional Study with Clinical Observation

A Master Thesis Research by:

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Postgraduate Resident in Pediatric Dentistry

Submitted in fulfillment of the requirements for the degree in Master of Science (Dentistry)

To
Deanship of Postgraduate Studies

Riyadh Elm University, Riyadh, Saudi Arabia

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- Dr. Sunil Babu Kotha …….
- Dr. Alwaleed Abushanan …….

Dedication

إهداء

و لأن من لا يشكر الناس لا يشكر الله و لأنّ الفضل بيننا لا يُنسى، احب ان أهدي هذه الرسالة بلغتي الأم لعلها اقرب للقلوب و الاصدق في إيصال مشاعرنا

أهدي هذه الرسالة الى

من كانت الداعمة الأولى ، الى من علمتني ان الدنيا كفاح و سلاحها العلم والتعلّم ، الى العظيمة التي يرجع لها الفضل بعد الله في كل انجاز أخطو اليه ، الى من حاوطتني بالدعاء حتى تسهلت كل الصعاب

(والدتي حفظها الله و اطال الله بعمرها)

و الى من شهد بداية طريقي و لكن أمر الله أسبق، الى فقيد قلبي ، الحاضر في الروح طيّب الله ثراه ، مُمتد العطاء و دائم الدعم كريمٌ في قربه و في البعد

(والدي رحمة الله عليه)

الى من انتظروا هذه اللحظات ليفخروا بي ، سندي في هذه الحياة و ملاذي الآمن ، لأصحاب الشدائد و الأزمات

(إخوتي و أخواتي)

الى كل من كان جزء من إنجازي ويبهجهم نجاحي ، الى كل من مدّ يد العون و سعى بأن أكون ما انا عليه اليوم ، للأصدقاء الأوفياء و رفقاء السنين

و لكل عائلة وثقت بي و جعلت مني طبيبة لأطفالها ..

أهديكم ثمرة جهدي في هذا البحث

اللهم لك الحمد حتى ترضى و لك الحمد اذا رضيت، و لك الحمد بعد الرضى

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Contents

Abbreviations

BS-CP	Bilateral spastic cerebral palsy
CDC	The Centre for Disease Control and Prevention
CI	Class I
CII	Class II
CIII	Class III
CII DIV1	Class II Division 1
CII DIV2	Class II Division 2
CP	Cerebral Palsy
DMFT	Decayed, Missing and Filled Teeth
EDACS	The Eating and Drinking Ability Classification System
FCCS	The Function Communication Classification System
GBD	The Global Burden of Disease
GERD	Gastroesophageal Reflux Disease
GMFCS	The Gross Motor Function Classification System
HIC	High-Income Countries
ID	Intellectual Disability
IRB	Institutional Review Board
LMIC	Low-Middle-Income Countries
MACS	The Manual Ability Classification System
OD	Oropharyngeal Dysphagia
SCPE	Surveillance of Cerebral Palsy in Europe

SBAHC	Sultan Bin Abdulaziz Humanitarian City
SHCN	Special Health Care Needs
TSL	Tooth Surface Loss
TMDs	Temporomandibular Disorders
UMIC	Upper-Middle-Income Countries
YLDs	Years of Life Lived With Disability

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Abstract

Background: Cerebral palsy (CP) is a neuromuscular disability, defined as a group of permanent problems affecting the development of movement and posture that result in limited activity and are caused by non-progressive disorders that occurred in the developing brain of fetus or infant. (CP) children are more likely to develop malocclusion due to hypotonia of facial muscles, mouth breathing, tongue thrusting, and swallowing problems.

Aim: To determine the prevalence of dental malocclusion and oral habits among various sub-types of patients with spastic cerebral palsy (diplegia, hemiplegia, and quadriplegia) in Riyadh City.

Materials and methods: A cross-sectional study included (n=231) children with different subtypes of spastic cerebral palsy aged between 4 to 15 years old were enrolled in two rehabilitation institutions in Riyadh City. Data was collected after taking complete case history followed by clinical examination. History includes socio-demographics, medical history, and oral habits. Clinical examination assessed dental occlusion in all dentitions i.e. overjet, overbite, and crossbites.

Results: Among all spastic subtypes in primary and mixed dentition, mesial step was the most prevalent molar relationship. Diplegia and hemiplegia showed a CI Canine relationship while quadriplegia showed a CIII Canine relationship in the primary dentition. All the hemiplegia samples with permanent dentition showed a CI canine relationship, CII molar relationship and CII Div1 incisor relationship. Increased overjet was higher in hemiplegia children with significant differences ($p<0.001$) between other types. Regarding bite categories, the deep bite was the most observed without statistically significant differences between other types ($p\leq0.143$). Children with quadriplegia were more likely to have anterior and posterior crossbites with significant differences between other degree ($p=0.026$ and $p=0.001$ respectively). Oral breathing was the most common observed habit among all types with no significant differences. The habit of thumb sucking, and tongue thrusting was significantly more prevalent in quadriplegias than other types.

Conclusions: Different types of spastic CP have different relationships depend on the type of dentition. Oral breathing habit was the most observed habit with no statistically significant differences among all subtypes. Thumb sucking and tongue thrusting were more common among quadriplegic children.

Keywords: Cerebral palsy (CP), malocclusion , spastic diplegia, spastic hemiplegia, spastic quadriplegia, oral habits.

CHAPTER I: INTRODUCTION

1.1 Overview

Cerebral palsy (CP) is an example of a neuromuscular disability which is defined as a group of permanent disorders of the development of movement and posture that result in activity limitations and are due to non-progressive disorders that have occurred in the developing fetal or infant brain (Rosenbaum et al., 2007). CP is characterized by secondary musculoskeletal problems, epilepsy, and cognitive disorders in communication and behavior (Rosenbaum et al., 2007). The etiology of the CP is multifactorial; an exact etiology can only be determined in 40 to 50% of cases, while in 30% of cases, the causes are unknown (Sehrawat et al., 2014). The periods in which CP may occur are prenatal, perinatal, and postnatal periods (Sehrawat et al., 2014). The majority of cases of CP are attributed to prenatal factors, while only a small percentage is due to birth asphyxia (Sehrawat et al., 2014).

According to the literature, there are different figures for prevalence in the population worldwide CP range between 1 to 5 per 100 infants (Danis and Kutluk, 2021). It has been estimated that South Africa has the highest prevalence, at up to 10 per 1000 live births (Couper, 2002). The prevalence of CP has been found to be 2.3 per 1000 children in 13 Saudi Arabian regions, including the central, western, eastern, northern, and southern regions (Al Salloum et al., 2011). The prevalence rate is within the range of CP in developing countries (Al Salloum et al., 2011). According to the Surveillance of Cerebral Palsy in Europe (SCPE) network, different types have been classified based on the symptoms that indicate a pathological condition of the cerebral musculoskeletal system, and there is a common abnormal pattern of movement and posture in all types of CP (Cans et al., 2007). The first form is the spastic form, which affects about 80% of cases and is characterized by stiff muscles; the second form is the dyskinetic or athetoid form which is less common than the spastic form and affects 10-20% of people and is characterized by uncontrollable

movements; the third form is the ataxic form, which affects 5% of cases and is characterized by poor coordination (Vitrikas et al., 2020). Spasticity in CP is classified according to the location and distribution of neuromotor impairments in the limbs according to topography classification. It is classified as diplegia effects occurring on the lower extremities, hemiplegia effects occurring on one side of the body, quadriplegia, a severe form of CP that affects all four extremities, and monoplegia effects occurring on one limb (Ogoke, 2018; Dougherty, 2009).

A healthy mouth is an essential component of a healthy body, and children with CP have an increased risk of dental disease compared to normal children (Wasnik et al., 2020). Due to neuromuscular disorders in these children, there is a high prevalence of dental caries, bruxism, uncomplicated tooth fractures, and malocclusion (Wasnik et al., 2020). Cerebral palsy condition in children can cause malocclusion & facial deformities. Research on these dates back to the 1950s by Chalmers Lyons's evaluation (Lyons, 1956). It has been reported that 59-92% of CP may be affected by malocclusion, and the most common malocclusion in CP is class II (CII) with anterior open bites (Sehrawat et al., 2014). There are several contributing factors associated with the prevalence of malocclusions among CP, which is mainly depending on the degree of impairment, including abnormal musculoskeletal development, oral breathing, changed relationships between the cranium and the base of the skull, premature eruption of the teeth, and lip incompetence (Miamoto et al., 2010; Jan and Jan, 2016). The severity of these abnormalities has been reported to increase with age (Miamoto et al., 2010; Jan and Jan, 2016). Researchers have been interested in malocclusion because it has a number of functional, aesthetic, psychological, and social effects (Martínez-Mihi et al., 2022). Studies have been conducted in Saudi Arabia on malocclusions in spastic cerebral palsy (Wyne et al., 1996). This study is unique in examining the prevalence of

malocclusion in each of the three subtypes of spastic cerebral palsy (diplegia, hemiplegia, quadriplegia and monoplegia).

1.2 Aim of the study:

The purpose of this study is to determine the prevalence of dental malocclusion and oral habits among various subtypes of patients with spastic cerebral palsy, including (diplegia, hemiplegia, quadriplegia, and monoplegia) in Riyadh City - Saudi Arabia.

1.3 Objectives of the study:

- To assess the relationship between teeth , including:
    - Molar , canine & incisors relationship
    - Overjet & overbite
    - Crossbites
- To determine any oral habits (oral breathing/ tongue thrusting/ abnormal swallowing / thumb sucking/ lip or nail biting/ bruxism).

CHAPTER II: LITERATURE REVIEW

2.1 CEREBRAL PALSY (CP)

2.1.1 History

For over 150 years, there has been a debate about the exact definition of cerebral palsy (CP) and how to best classify its various forms (Morris, 2007). The etiology and pathogeny of CP indicate that CP existed in the ancient world. Between the end of the 19th dynasty (1196-1190 B.C.) in ancient Egypt, the preserved corpse mummy of Pharaoh Siptah is considered to be one of the earliest examples of CP (Panteliadis et al., 2013).

Photographs of the Pharaoh's marked foot deformity have been published in medical literature to illustrate this case of CP (Panteliadis et al., 2013). Ikram and Dodson, in 1998, state that the mummy's left foot of the Pharaoh's was stretched because of a shortened Achilles tendon, according to Egyptologists (Figure 1). This observation was considered to be suggestive of CP (Ikram and Dodson, 1998).

Figure 1.The mummified Pharaoh Siptah (died 1191 BCE) had talipes equinovarus (club foot) and most likely suffered from poliomyelitis or possibly cerebral palsy. Photograph from The Royal Mummies by G. Elliot Smith (1912) (Smith, 1912)

A Greek physician known as Hippocrates was considered the father of medicine in ancient Greece. Corpus Hippocraticum was Hippocrates' work where he described CP for the first time (Panteliadis et al., 2013). Hippocrates was the first to explore the connection between prematurity, congenital infection, and prenatal stress in relation to the development of brain injury. In his work “Of the Eight-Month Foetus”, Hippocrates describes infants with "intrauterine disease" as having higher rates of illness and death. Hippocrates was the first to observe that women who experienced foetal distress during the 8th month of pregnancy were more likely to give birth to children with physical disabilities. Additionally, he noted that pregnant women who had an unexplained fever or excessive weight loss were at risk of experiencing difficult and dangerous childbirth or even miscarriage (Panteliadis et al., 2013).

The etymology of the term "palsy" can be traced back to Ancient Greece. The term may have originated from the word "paralysis," which was employed by physician Galino to describe “weakness and complete or partial death of the nerves in the limbs.” In the early to middle nineteenth century, significant advancements were made in the study of CP. Several individuals contributed to the understanding of this condition and its underlying causes. One of these pioneers was William John Little (1810–1894), an English physician (Figure 2) who was the first physician to extensively study CP and its effects on motor development. Little's work laid the foundation for future research in this field (Panteliadis et al., 2013). He was diagnosed with poliomyelitis at age four, leading to a left clubfoot. Upon completing his residency program, he had an operation to correct his own clubfoot, which was a success. Hence, for his doctoral thesis, he performed the same operation with some changes on thirty patients with clubfoot (Schifrin and Longo, 2000). This led to the ongoing association between William John Little's name and CP, by which time it was widely referred to as 'Little's Disease' then he coined the name to the cerebral paresis in 1861

(Schifrin and Longo, 2000; Dougherty, 2009). In the late 19th century, after Little's work, there were two more major personalities contributed to the historical hallmarks of cerebral palsy: William Osler and Sigmund Freud (Panteliadis et al., 2013).

Fig. 1. Portrait of William John Little (1810–1894).

Figure 2. William John Little (1810–1894), an English physician (Schifrin and Longo, 2000)

2.1.2 Definition

Several definitions of CP already exist in the literature by a number of writers between 1950 and 2000. Polani, Mac Keith (1959), and Bax (1964) are examples (Rosenbaum et al., 2007). Mutch

modified the definition of CP in 1992 as follows: “an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of development” (Mutch et al., 1992). The SCPE (Surveillance of cerebral palsy in Europe 2000) paper states that CP is a group of permanent disorder, but not unchanging, disorders of movement and/or posture and of motor function, which are due to a non-progressive interference, lesion, or abnormality of the developing/immature brain," was written by a consortium of European professionals working in the field of CP (Cans, 2000). CP refers to a collection of lifelong abnormalities of posture and movement development that lead to a restriction in activities. These restrictions are often accompanied by seizures, secondary musculoskeletal issues, and changes in sensation, perception, cognition, communication, and behavior (Rosenbaum et al., 2007). In accordance with the definition, some people with CP also have other neurodevelopmental disorders or impairments, such as intellectual disabilities, which are the most commonly associated impairments encountered among children with CP (Rosenbaum et al., 2007). The second most frequently associated impairment is epilepsy which may appear early in life or not until school age. Many studies report that about 30% of people with CP have active epilepsy varying in type depending on the type of brain anomaly (Carlsson et al., 2003; Venkateswaran and Shevell, 2008).

2.1.3 Prevalence

2.1.3.1 Prevalence Wordwide:

Around the world, CP is the most common form of neuromuscular disability that affects children (Dougherty, 2009). According to the global burden of disease (GBD) Study in 2019, the total number of people affected with CP worldwide is estimated to be about 50.0 million (Figure 3).

The condition contributes to 11 million years of life lived with disability (YLDs), requiring long-term rehabilitation (Cieza et al., 2020).

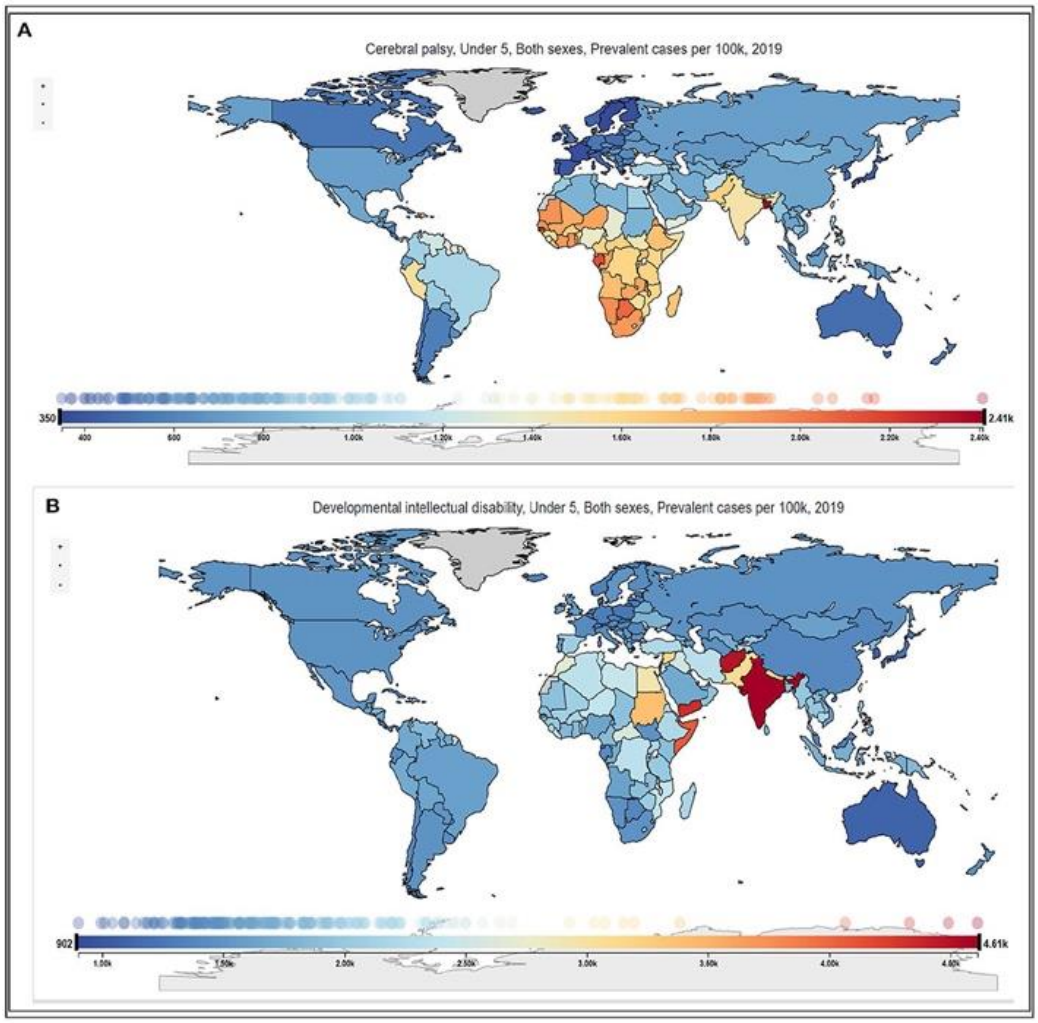

Figure 3. Global prevalence per 100,000 population of cerebral palsy and developmental intellectual disability among children under 5 years in 2019. (Olusanya et al., 2022)

According to the literature, a variation in prevalence has been noted around the world from 1-5 per 1000 infants with an overall prevalence of 2.11 per 1000 live births (Danis and Kutluk, 2021). It is reported that the prevalence of CP is tracked by an increasing number of registries worldwide (Goldsmith et al., 2016). In the United States and Europe, CP prevalence rates have not decreased over the past 30 years, on the contrary, the cases have increased (Dougherty, 2009). In Europe and

Australia, the prevalence was reported that between 1.7 to 2 per 1000 live births. The Centre for Disease Control and Prevention (CDC) in Atlanta conducted a population-based study in the United States. They found that the rate of a certain condition among children born between 1985 and 2002, when they reached 8 years of age, was 2.2 per 1000 children (Van Naarden Braun et al., 2016). In Turkey, the estimated prevalence is 4.4 per 1000 live births (Danis and Kutluk, 2021) and in South Africa, it might be as high as 10 per 1000 live births (Couper, 2002).

2.1.3.2 Prevalence in Arabic-Speaking Countries:

A recent systematic review was conducted by Mushta and his colleagues in 2022 to assess the prevalence of CP in different Arabic-speaking countries. The seven studies included in the analysis were from Egypt, Saudi Arabia, and Jordan, which are classified as low-middle-income countries (LMIC), high-income countries (HIC), and upper-middle-income countries (UMIC), respectively (Mushta et al., 2022). The overall pooled estimate of CP birth prevalence, combining hospital-based and community-based data, was 1.8 per 1,000 live births, and spastic CP is the most common type (Mushta et al., 2022).

2.1.3.3 Prevalence in Saudi Arabia:

The Kingdom of Saudi Arabia occupies approximately one-fifth of the Arabian Peninsula with a population of approximately 28,376,355. A report states that 13% of this population has a disability that limits their independence, most commonly is CP followed by road traffic accidents. The following are the most common causes of death, hospitalization, and chronic disability in the Kingdom of Saudi Arabia (Al-Jadid, 2013). CP prevalence in Saudi Arabia varies across studies, though there is a lack of research on this condition (Al-Jadid, 2013). One study conducted in

Jeddah reported a prevalence of 1.6 per 1000 live births (Al-Jabri et al., 2022). While Another study in Medina found a prevalence of 3.5 per 1000 live births (El-Halaby et al., 2020).

However, the last published prevalence number was released by AlSalloum et al. in 2011 in a community-based study including all regions of Saudi Arabia: the central, western, eastern, northern, and southern regions. It was found in 13 Saudi Arabian regions that the prevalence of CP was 2.3 per 1000 children. The prevalence rate is within the range of CP in developing countries (Al Salloum et al., 2011).

2.1.3.4 Factors Affecting CP Prevalence:

Prevalence of CP is strongly associated with birth weight and gestational age. A higher prevalence of CP was observed in children weighing 1000 to 1499g with a rate of 63 per 1000 infants and a lower prevalence in children weighing over 2500g with a rate of 11 per 1000 infants. There is an inverse relationship between the gestational age and CP condition; it shows that if the gestational age increases, the probability of the occurrence of CP will decrease. for gestational age, the rate is 1 per 1000 live births in children born at term, 7–10 times higher for children born moderately preterm (i.e., 32–36 weeks gestational age), and 60 times higher for children born very preterm (i.e., before 32 weeks gestational age) (Oskoui et al., 2013).

In addition, CP is more prevalent among twins compared to those born as singletons by four times. The surviving twin may also be at an increased risk of developing CP if a co-twin is lost too early. An increased proportion of twins born in normal delivery were for the second-born twin, possibly due to an increased risk of intrapartum asphyxia more than the first-born twin (Topp et al., 2004). The prevalence varies according to race/ethnicity, with a higher prevalence rate for non-Hispanic black children than for non-Hispanic white children (Kirby et al., 2011). According to the

systematic review conducted in Arabic-speaking countries, it's reported that 37.7% of children having CP were born from consanguineous marriages, which is very common in Arabic societies (Mushta et al., 2022).

2.1.4 Etiological Factors:

The etiology of the CP is multifactorial, and when looking at etiological risk factors, traditionally within the context of CP, they are considered by likely timing of exposure, i.e., pre-conception (status of the mother's health), prenatal, perinatal (i.e., around the time of birth, usually from 28th week of pregnancy until 7th day of life), and postnatal periods. In the past century, infant brain hypoxia during labor in the perinatal period has been considered the most common cause of CP cases, but after many years of researching, it has been determined that 75% of its causes occur during the prenatal period (Sadowska et al., 2020). It is possible to identify the exact cause only in 40% to 50% of cases, while 30% of cases exhibit no risk factors at all (Sehrawat et al., 2014). On the other hand, it has been reported in Saudi Arabia that CP is actually caused mainly by perinatal and postnatal factors. It is estimated that 30% of CP cases can be prevented if preventive methods are taken during these two periods (Taha and Mahdi, 1984). About 8% of cases of CP occur at an older age, usually from head injuries or infections (Vitrikas et al., 2020).

Detailed (Figure 4) illustrated risk factors adopted from (Sadowska et al., 2020).

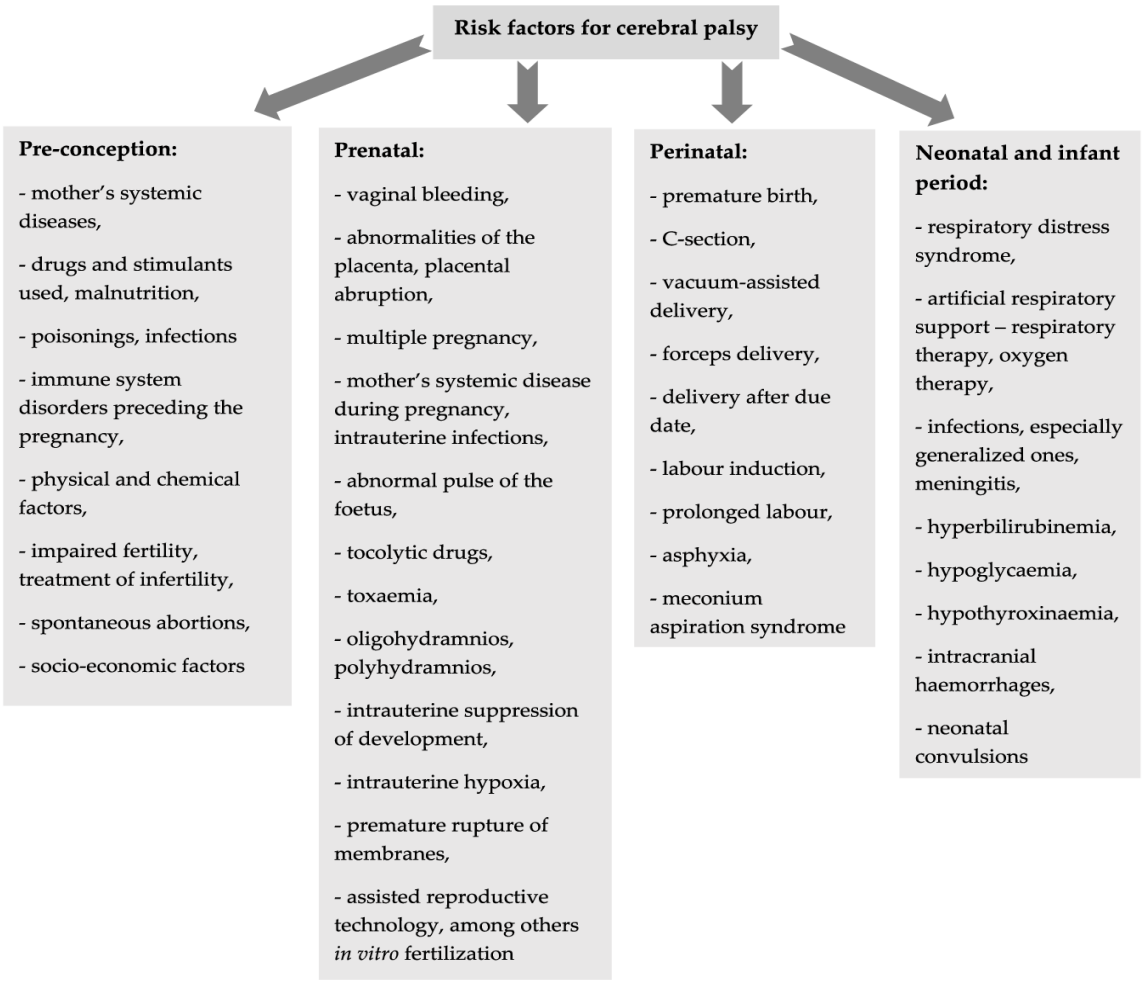

Figure 4. Risk factors association with CP condition adopted from (Sadowska et al., 2020)

2.1.5 Classifications:

Classification can serve several purposes such as monitoring subgroups of CP who is expected to change over time. Research on CP's etiology and comparisons with other studies and interventions for children with CP based on motor impairment severity. Classification means 'the basic cognitive process of distributing children with CP into classes or categories of the same type', and there are different classification systems based on clinical findings such as motor disability, body

distribution, and severity. Clinical findings-based classification systems are currently the most widely used, and they could serve different purposes (Cans et al., 2007).

A child with CP differs clinically in the following ways: type/nature of motor disorder, motor impairment distribution, causes of the condition, other impairments accompanied by motor impairment, abnormal brain structure on imaging, severity of impairment, and individual requirements for treatment. Traditional classifications of CP are based on these clinical variables. (Ogoke, 2018)

2.1.5.1 Classification Based on Motor Type and Topographical Distribution:

The Surveillance for Cerebral Palsy in Europe (SCPE) classification is one of the best and simplest classifications to describe a patient with CP based on a multiple variables system. It was proposed recently by the European SCPE network; this type of classification tree are divides CP into four subtype groups (Figure 5) (Ogoke, 2018):

1. Spastic, including (Bilateral and unilateral): Bilateral CP is diagnosed if limbs on both sides of the body are involved, and Unilateral CP is diagnosed if limbs on one side of the body are involved.
2. Dyskinetic (dystonic and choreoathetotic).
3. Ataxic.
4. Non-classifiable

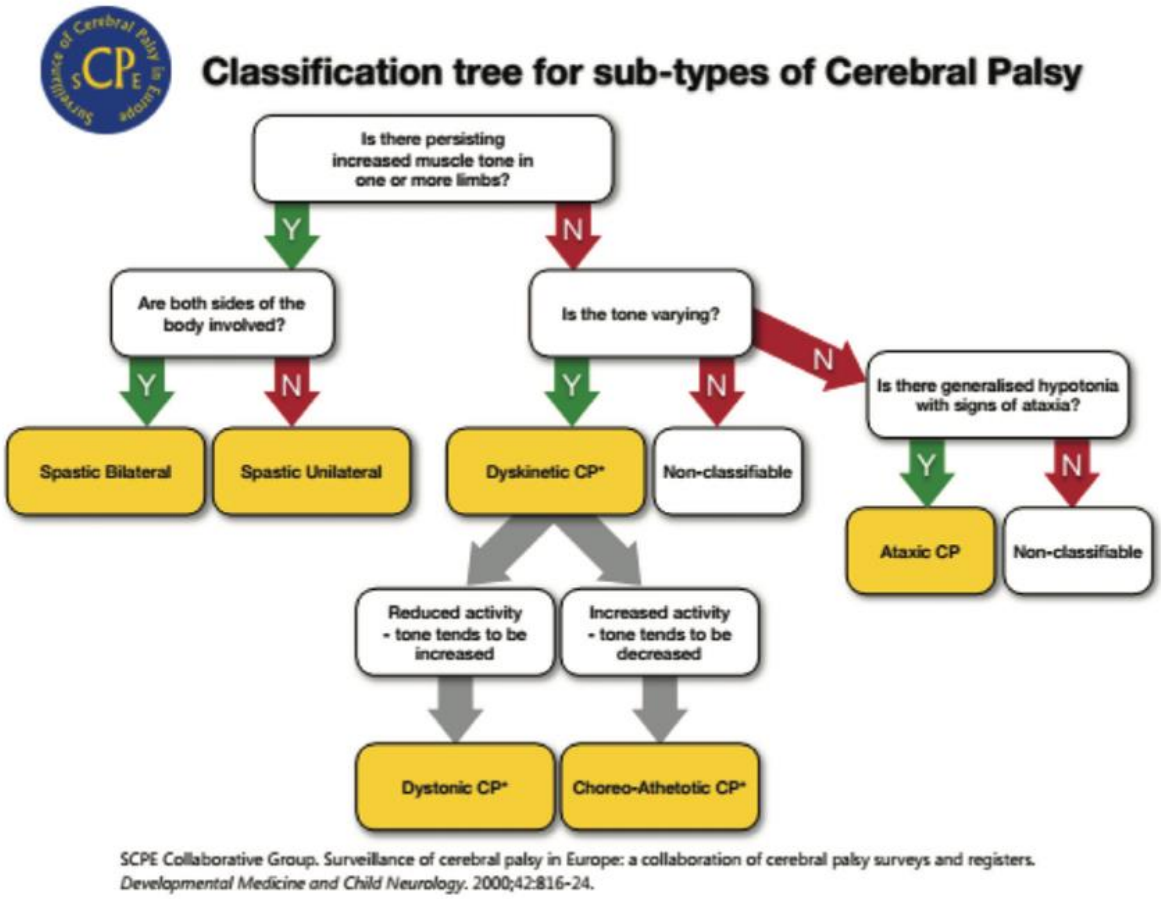

Figure 5. The classification tree for CP.

There is a common characteristic of all types of CP, which is abnormal posture or movement, However, each type has a unique characteristic. Spastic CP it is the most common type accounting for 70% to 80% of all diagnoses. characterized by stiff muscles and difficulty controlling movement. An upper motor neurons injury causes this type of CP. Dyskinetic CP is dominated by involuntary, uncontrolled movements with difficulties and slow of controlling the posture. This type occurred in 10-15% of children with CP. A deep motor neurons injury causes this type of CP. Lastly, ataxic type of CP has a small percentage of cases with a 5% incidence. It is s characterized by poor muscular coordination, so movements are performed with abnormal balance, rhythm, and

accuracy. Cerebellar neurons are damaged, resulting in this condition (Cans et al., 2007; Dougherty, 2009).

According to topography classification, the global burden of disease (GBD) spasticity in CP is classified according to the location and distribution of neuromotor impairment in the limbs. These spasticity can be characterized as diplegia (30% to 40%), effects on the lower extremities, and also possible to have an effect on the arms, but it is less severe. Hemiplegia (20% to 30%) effects happen on one side of the body; legs are usually less involved than arms. More than 60% of hemiplegia types have normal mental health and are able to do more without assistance. Quadriplegia (10% to 15%) is a severe form of CP resulting in the effects on all four extremities. The majority of these individuals suffer from intellectual disabilities and epilepsy. Monoplegia, which is the most rare condition, includes one-limb spasticity in an arm or leg (Ogoke, 2018; Dougherty, 2009).

Quadriplegia, diplegia, and hemiplegia in the topographic classification were replaced by two new terms introduced by SCPE. The terms bilateral and unilateral describe the involvement of two sides or one side of the body, respectively. By this classification, spastic quadriplegia and spastic diplegia are classified as bilateral spastic CP (BS-CP), while spastic hemiplegia is termed unilateral spastic CP (Ogoke, 2018).

In the SCPE database, half of the children with CP have a bilateral spastic type, nearly a third a unilateral spastic type, and the others have either a dyskinetic or an ataxic type. When more than one type is present, i.e. spasticity with ataxia and/or dyskinesia, the child should be classified according to the dominant clinical feature (Cans et al., 2007).

2.1.5.2 Classification Based on Motor Functional Loss:

During the last decades, scales have been devised specifically for children with CP to assess the loss of motor function in both the lower and the upper limbs, with the aim of increasing the comparability of assessments between professionals and geographically diverse research groups. The Gross Motor Function Classification System (GMFCS) describes the severity of movement disability for children with CP. It is a five-point scale for the trunk and lower limb motor function. It was published by Palisano et al in 1997 to assess and categorize the degree of gross motor participation in CP patients (Palisano et al., 1997). Originally, it was only until 12 years old, but they have extended it to 18 years of age in the updated version (Palisano et al., 2009). From Level I, which has the greatest independent motor function, to Level V, which has the least voluntary control over movement and the least capacity to sustain antigravity head and trunk postures. (GMFCS) divides gross motor function into five levels at a various age group with descriptions of the skills: younger than 2 years of age, from 2 to 4 years of age, from 4 to 6 years of age, from 6 to 12 years of age, and finally 12 to 18 years of age. For every level, developmental curves have been created, which is useful for educating parents about the prognosis of motor function. In general, the levels are given in (Figure 6) 1A to E (Sehrawat et al., 2014).

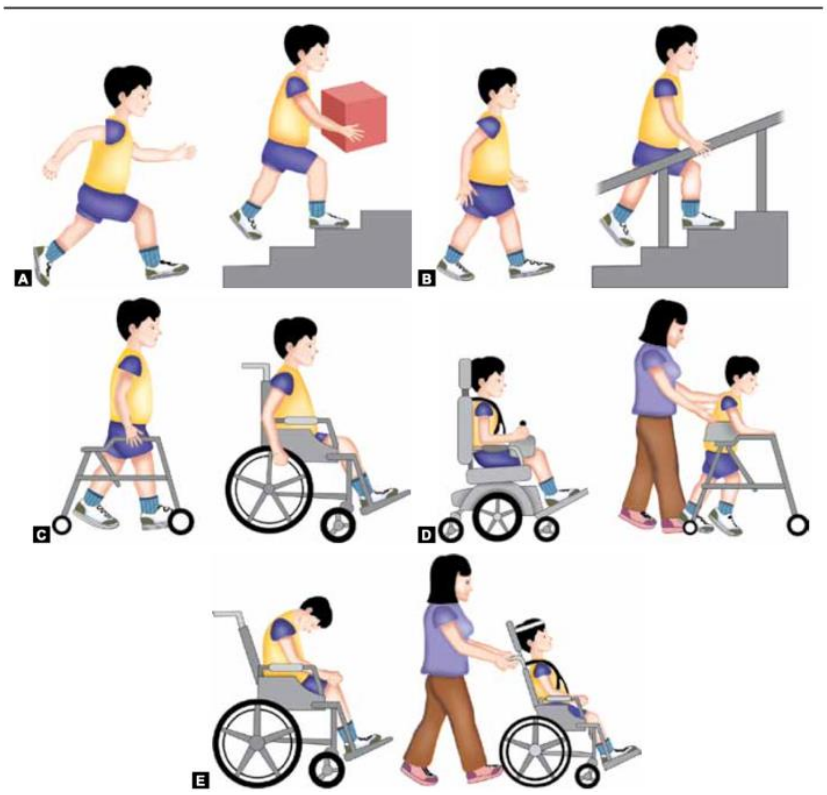

Figure 6. Gross motor function classification system (GMFCS): (A) Level I—walks without limitations, (B) Level II—walks with limitations, (C) Level III — walks using a hand-held mobility device, (D) Level IV — self-mobility with limitations may use powered mobility and (E) Level V—transported in a manual wheelchair (Sehrawat et al., 2014)

Similarly, with a five-point scale for the upper body, which is The Manual Ability Classification System (MACS), children with CP are assessed on how often they can handle objects with their hands in daily life (Eliasson et al., 2006). Level I children are capable of performing all manual tasks and handling objects easily compared to level V, children at this level are completely dependent and have very limited ability to perform even simple tasks. In collaboration with a health care professional, parents or caregivers observe the child's function in daily life to determine the levels (Jeevanantham et al., 2015).

2.1.5.3 Classification Based on Associated Impairment:

Approximately 36% to 60% of children with CP may also experience motor speech and communication problems related to brain injury. The Function Communication Classification System (FCCS) was adopted in 2006 for young children aged between 4 to 5 years with communication difficulties and also to assess how the child can be able to communicate (Barty et al., 2016).

The ability to eat, drink, and swallow can be affected in children with CP. Indirect aspiration of food and fluid into the lungs can cause respiratory problems in these children. The Eating and Drinking Ability Classification System (EDACS) is another classification proposed in 2014 to assess the eating and drinking Ability of children with CP. (EDACS) is a similar and complementary system to the GMFCS, including five levels (Figure 7) (Sellers et al., 2014).

Level	GMFCS	EDACS	EDACS levels of assistance
I	Walks without limitations	Eats and drinks safely and efficiently	Independent
II	Walks with limitations	Eats and drinks safely but with some limitations to efficiency	Requires assistance
III	Walks using a hand-held mobility device	Eats and drinks with some limitations to safety; there may be limitations to efficiency	Totally dependent
IV	Self-mobility with limitations; may use powered mobility	Eats and drinks with significant limitations to safety	
V	Transported in a manual wheelchair	Unable to eat and drink safely – tube feeding may be considered to provide nutrition	

Figure 7. (EDACS) is a similar and complementary system to the GMFCS, including five levels (Sellers et al., 2014)

2.1.6 General Clinical Manifestation and Complications Associated with CP:

In addition to CP with a permanent disorder of movement, several other complications can also occur, such as intellectual disability, epilepsy, sialorrhea, vision, speaking problems, and hearing loss. The initial assessment should include early screening for these complications, and early management could enhance their quality of life and improve their rehabilitation progress (Alhashmi et al., 2017).

2.1.6.1 Intellectual Disability (ID):

CP is most commonly accompanied by intellectual disability(ID), although this is not a diagnostic feature that has a negative impact on daily and quality of life. The term ID is used to describe a significant delay in more than one developmental domain by younger than 5 years of age or a lower intelligence quotient of 70 or less at an older age (Sadowska et al., 2020; Dougherty, 2009). Different subtypes of CP have different prevalence rates, but it is estimated that 50% of individuals with CP will develop ID (Vitrikas et al., 2020). It is not mandatory that ID be present in every case of CP, but it is more likely to be present in severe cases such as quadriplegic type than those diagnosed with diplegic or hemiplegic type of CP. A number of factors, including epilepsy and cortical abnormalities, are commonly associated with CP that can increase the risk of ID (Alhashmi et al., 2017).

2.1.6.2 Epilepsy:

Children with CP have a high incidence of epilepsy, ranging between 15% to 60%, which is a very common clinical problem. A high percentage of CP will have it within the first 4-5 years of their lives mostly in the first year. The severity of neurological damage can be determined by epilepsy.

Based on the type of CP, epilepsy incidence varies, as in the quadriplegic type of CP, the risk of developing epilepsy is highest by (50-94%). CP patients with diplegia and ataxic are less likely to suffer from this problem (16–27%) (Sadowska et al., 2020; Alhashmi et al., 2017).

2.1.6.3 Sialorrhea:

Approximately the rate of drooling of saliva in CP children ranges from 10% to 58%. In some cases, drooling isn't associated with the high amount of production of saliva, but it can be a secondary symptom of difficulty swallowing, opening the mouth, or both. Physical health and quality of life are adversely affected by drooling of saliva in the anterior oral cavity. It can cause aspiration, skin irritation, articulation problems, and social embarrassment (Sehrawat et al., 2014; Alhashmi et al., 2017).

2.1.6.4 Speech Problems:

More than 50% of Children with CP may suffer from dysarthria which is defined by difficulty, weak or slow in articulating words caused by impairment of the speech muscles. In CP, any of the functions involved in producing speech are hampered, including respiration, laryngeal, velopharyngeal, and articulatory movements. There is a relationship between speech ability and the type of CP, gross motor function, the presence of intellectual disability, and the location of the damage in the brain. A child with unilateral spastic CP has a 90% chance of speaking normally, compared to 97% of a child with dyskinetic CP. Management of the CP patient's feeding and swallowing problems, as well as speech therapy, help make them able to communicate (Sehrawat et al., 2014; Alhashmi et al., 2017).

2.1.6.5 Vision problem:

Visual impairment is more prevalent in children with CP by 25-29%. There are a variety of impairments associated with CP conditions, such as myopia, strabismus, and others. As a preventative measure, vision screening should be performed at 12 months and four years of age, followed by periodic screenings (Alhashmi et al., 2017; Vitrikas et al., 2020).

2.1.6.6 Hearing loss:

Hearing loss may also occur in children with CP, ranging from 8-18%. In the first year of life and every six months until the age of three, hearing screening is recommended. Detection and treating hearing loss early can prevent more development delays in CP patients. Several risk factors can cause hearing loss, such as rubella and meningitis (Alhashmi et al., 2017; Vitrikas et al., 2020).

2.1.6.7 Swallowing Disorders:

A prevalence of over 90% has been reported for oropharyngeal dysphagia (OD) in children with CP. Due to an incoordination between swallowing and breathing, OD occurs. It is generally silent and associated with common problems such as respiratory infections, aspiration pneumonia, and dehydration. Children with CP are being tube fed around 10% between the ages of 18 and 36 months, and 39% have modified food textures (Marpole et al., 2020). CP children with feeding and swallowing problems have severe nutrient deficiencies, which lead to malnutrition, dehydration, altered growth, and micronutrient deficiencies. Because of the high nutritional demands needed for growth and development, children and adolescents are more likely to suffer from poor nutrition than adults. As a result, health and development may be adversely affected (Costa et al., 2021).

It is necessary for a speech therapist to assess dysphagia to ensure that oral feeding is safe and nutritionally adequate (Marpole et al., 2020).

2.1.6.8 Mouth Breathing:

As a multifactorial syndrome, there are many complications associated with mouth breathing, such as bad oral hygiene, malocclusion, sleep disorder, speech and hearing problems, and impact on quality of life. Mixed “mouth and nose” breathing is more common among individuals with CP, ranging from 60% to 86%, decreasing with age. Patients with developmental disabilities, such as those with CP, have few studies investigating the factors associated with mouth breathing (de Castilho et al., 2016).

CP children frequently suffers from epilepsy, and medications for treating this condition may cause mouth breathing, such as benzodiazepines. It is known that benzodiazepines can cause hypoxia, and they can alter breathing patterns, especially during sleep. Consequently, mouth breathing becomes an alternative to increase oxygen uptake due to compromised nasal breathing (de Castilho et al., 2016).

2.1.7 Common Dental Problems in Cerebral Palsy:

A healthy mouth is an integral part of a healthy body. people with special health care needs (SHCN) have a higher risk of developing oral diseases that can affect both general health and quality of life (Wasnik et al., 2020). Oral health can be significantly affected by neuromuscular problems associated with CP. A change in orofacial anatomy causes these patients to have parafunctional habits, feeding difficulties, excessive salivation, and malocclusions (Dougherty, 2009). Access to oral care, difficulties with feeding, and oral hygiene maintenance may result from these modifications. As a result of neurological problems, which include motor and coordination difficulties, in addition to poor oral hygiene, dental disease is more likely to develop (Jan and Jan, 2016).

Several factors contribute to the increased susceptibility of these children to dental disease, including the use of multiple medications, inadequate oral hygiene practices, a soft or cariogenic diet, periodontal disease, and nutrition through a gastrostomy tube (Escanilla-Casal et al., 2014).

Oral complications do not invariably ensue from CP. However, due to the co-occurrence of numerous symptoms, children with CP are more prone to experiencing challenges that diminish their overall quality of life (Jan and Jan, 2016).

A correlation has been established between the subsequent risk factors and established processes:

- Motor and cognitive decline resulting in compromised oral hygiene, increased dependence on a caregiver, and reduced involvement of the dental team.
- Difficulties with digestion, chewing, and drooling brought on by pseudo-bulbar palsy.
- Insufficiency of vitamin D and calcium consumption are complications of malnutrition.
- Gastroesophageal reflux disease (GERD) induces symptoms including vomiting, enamel erosion, and the risk of aspiration (Jan and Jan, 2016).

2.1.7.1 Dental Caries:

Individuals with CP often report poor oral hygiene as a problem affecting their oral health. Dental caries involves a variety of biological, social, and environmental factors that affect quality of life (Jan and Jan, 2016). Patients with CP have a higher incidence of dental caries in both primary and permanent teeth compared to non-CP children. There are several factors contributing to this, such as the high number of elevated bacterial plaque counts, the difficulty in maintaining their oral health, the inability to handle a toothbrush, some medications that may cause xerostomia, and the type of food they eat, which is mainly soft food (Escanilla-Casal et al., 2014). Caries incidence is positively correlated with poor oral motor function such as mastication, food pouching,

swallowing, and mouth closure, can affect oral clearance times and caries prevalence. Caries risk appears to be significantly increased in CP children with low caregiver education levels. Also, it's reported that there is a positive relationship between ID and a high rate of caries experience. Spastic CP type, which is the predominant type, had more caries prevalence due to their high muscle spasticity (Cui et al., 2022). There was a high DMFS score for the CP children, indicating previous caries infection. Additionally, their plaque index was high, their mutans streptococci and lactobacillus counts were high, and their salivary flow rate was low (dos Santos et al., 2002).

Early rehabilitation, intervention, and prevention are important for these individuals. In addition, education programs should be developed for caregivers regarding oral health maintenance for these patients (Sehrawat et al., 2014; Cui et al., 2022). Among children with CP, plaque removal is recommended daily, sugar intake is reduced, fluoride varnishes are used, and saliva stimulation is encouraged (dos Santos et al., 2002).

2.1.7.2 Periodontal Disease:

Generally, compromised gingival health can be attributed to difficulties in maintaining proper dental hygiene practices. Risk factors include behaviours such as mouth breathing, food pouching, and inadequate neuromuscular control. Periodontal disease is predicted by gingival hyperplasia associated with the use of anticonvulsants like phenytoin (Jan and Jan, 2016).

2.1.7.3 Non- Carious Tooth Surface Loss:

A tooth surface loss (TSL) can occur from tooth erosion, which is irreversible tooth loss caused by chemical (non-bacterial) processes, or from attrition, which is wear from tooth-to-tooth contact. A number of causes can contribute to TSL, including intrinsic and extrinsic acid sources.

GERD is an example of the intrinsic acid source defined as the involuntary passage of gastric juice against the normal flow of the digestive tract. GERD is the most important cause of palatal dental erosion in 70% of CP children (Alhashmi et al., 2017). Dental erosion is common in CP patients; the majority of enamel erosion was observed in upper molars (54%), lower molars (58%), and upper incisors (54%) (Sehrawat et al., 2014).

2.1.7.4 Parafunctional Habits:

There are several parafunctional oral habits, including bruxism, tongue thrusts, thumb-sucking habits, and biting. Due to spasticity in CP children, they are more susceptible to oral parafunctional habits. Chewing and swallowing are both oral motor activities that will be negatively affected by these habits (Tuncer et al., 2023). According to Ortega et al., in 2007, children with CP were assessed from different parafunctional habits. As a result of the study, bruxism was found in 36% of the sample; 13% used a pacifier, 6% of them had thumb sucking, 18% biting objects, and 41% had had tongue thrust habit (Ortega et al., 2007). Several factors contributed to the development of parafunctional activity in CP patients, including spasticity, sleep problems, and lack of control of the mandibular posture (Alhashmi et al., 2017).

Bruxism may lead to teeth abrasion and flattening of biting surfaces. The term bruxism refers to movement disorders of the masticatory system characterized by teeth grinding and clenching while asleep and awake. This habit has been related to sucking habit, crossbite, and GERD (Alhashmi et al., 2017). Children who have no developmental disability are reported to have a prevalence of bruxism of between 8% to 31%, while it is 25% to 69% in children with CP. As a result of bruxism, several problems can occur, such as permanent damage to the jaw, loss of dental hard tissue, dysfunction of the temporomandibular joint, and sleep disorder (Tuncer et al., 2023).

However, the exact mechanisms responsible for the development of this habit remain unknown, but it is likely to be due to abnormal proprioception in the periodontium (Jan and Jan, 2016).

2.1.7.5 Enamel Defects:

There is a higher risk of developmental enamel defects in prematurely born children with CP. The enamel defects appear mainly in the primary incisors and first molars (Jan and Jan, 2016).

2.1.7.6 Dental Trauma:

CII malocclusions with prominent maxillary incisors with a combination of incompetent lips, difficulty walking, and seizures are common in individuals with CP, which predisposes them to dental trauma. The most common type of dental trauma among patients with CP is an uncomplicated dental injury with enamel and dentin fractures (Alhashmi et al., 2017).

As shown in Holan et al's study, dental trauma is significantly more prevalent in the CP population by 57% while 22% in general people (Holan et al., 2005).

2.1.7.7 Malocclusion:

2.1.7.7.1 Factors and Prevalence:

A variety of genetic and environmental factors are thought to be involved in the development of craniofacial structures and tooth positions. In terms of the development of malocclusion, the strength of the muscles of the orofacial region can play a role at rest as well as during function. Researchers have been interested in malocclusion because it has a number of functional, aesthetic, psychological, and social effects (Martínez-Mihi et al., 2022).

In patients with CP, oral-motor skills are often impaired, such as hyperactive or hypoactive gag reflexes, overextended bite reflexes, and muscular dysfunction of the cheeks and lips, preventing competent lip sealing, resulting in food/liquid loss (Santos et al., 2005).

CP condition in children can cause malocclusion & facial deformities. Research on these dates back to the 1950s by Chalmers Lyons's evaluation (Lyons, 1956). The prevalence of malocclusion in CP children ranges from 59 to 92% (Sehrawat et al., 2014). There are several contributing factors associated with the prevalence of malocclusions among CP, which is mainly depending on the degree of impairment, including abnormal musculoskeletal development, oral breathing, changed relationships between the cranium and the base of the skull, premature eruption of the teeth, and lip incompetence. The severity of these abnormalities has been reported to increase with age (Miamoto et al., 2010; Jan and Jan, 2016).

Malocclusions of an individual play a major role related to oral health and are associated with many dental problems such as periodontal disease and Temporomandibular disorders (TMDs) (Alhashmi et al., 2017). A vertically long face with class II molar relationship, anterior open bite, and increased dental overjet (maxillomandibular incisal anteroposterior discrepancy) is the most prevalent facial skeletal deformity observed in patients with CP (Martinez-Mihi et al., 2014; Miamoto et al., 2010).

As reported by Carmagnani et al. in 2007, It was found that the spastic type of CP has more incidence of CII malocclusion and open bite. Also, there is a higher incidence of CII malocclusion from primary to mixed dentition, but the incidence will decrease from mixed to permanent dentition. The ataxic CP group had a low level of malocclusion. (Carmagnani et al., 2007) There is a moderately elevated incidence of additional facial anomalies, such as orofacial clefts, among

patients diagnosed with CP. The occurrence of these congenital abnormalities is 2.9- 4.2 times greater in comparison to the general population (Pharoah, 2007).

Patients with CP were reported to require orthodontic treatment in 70.8% of cases (Martinez-Mihi et al., 2014).

2.1.7.7.2 Malocclusion and Breast Feeding:

The Stomatognathic system consists of hard and active components. There are numerous active parts, including muscles, spaces, nerves, and blood vessels. Maxilla, mandible, hyoid, and skull bones are considered hard parts. The entire system performs neuro vegetative functions (sucking, chewing, swallowing, breathing, speaking, and expressing facial expressions). A disorder in one of these structures will cause the entire system to become disorganized and unbalanced (Gomes et al., 2006).

The development of the craniofacial system is dependent on genetics as well as external stimuli. Muscles that work in breathing, sucking (breastfeeding), swallowing, and chewing can provide the major stimuli for growth as they stretch the bones. The quantity of suction infants perform significantly impacts their facial development. To generate the negative pressure required for effective milk aspiration from the breast, it is imperative to activate the facial muscles. The lips are responsible for establishing a tight seal, while the masticatory and tongue muscles initiate swallowing (Gomes et al., 2006).

According to research involving 1,303 ordinarily developing 5-year-olds, moderate to severe malocclusion, overjet, crossbite, and overbite were less prevalent in infants who were exclusively breastfed until they were 6 months old (Peres et al., 2015). It is common for children with CP to

demonstrate oral-motor involvement and compromised feeding abilities, which require feeding therapy; compared with children without oral-motor involvement, feeding problems are resolved quickly (Wilson and Hustad, 2009).

A study reported that 87% of children with CP engage in oral sucking habits such as bottle feeding or pacifier/finger sucking between the ages of three and twelve. By the time these behaviours reach skeletal maturation, they can negatively affect the development of children's orofacial structures, which results in malocclusion (Carneiro et al., 2017).

2.1.7.7.3 Postural Alterations:

There are several factors that may influence skeletal and dental occlusal disorders among CP patients, including the resting position of the head. It has been shown that a forward resting position increases the craniofacial angle, which correlates with vertical growth patterns and long faces (Solow et al., 1984). The best explanation for these associations comes from soft tissue stretching and muscle feedback systems, both of which are responsible for maintaining the resting position of the head and neck. Patient malocclusions are ultimately caused by any factor that alters the head's resting position for an extended period of time (Solow et al., 1984).

An increased prevalence of malocclusions has been observed to be related to the resting position of the head (Martinez-Mihi et al., 2014). Bone development is already compromised in patients with CP as a result of postural abnormalities. Martinez-Mihi et al. evaluated the head-holding behaviours of CP patients in 2013. Postural alterations are suggestive of abnormalities in neuromuscular functioning, as determined by their examination of 44 adult subjects. They observed that their patients frequently held their necks low and had a forward hyperextended posture. A greater craniofacial angle is produced when an individual rest their head forward or

hyperextended, as opposed to when they rest their cranium contracted. When this occurs mechanically, the soft tissues in the lower face are stretched, and the bones are pulled. Clockwise rotation is a condition wherein the patient is pulled backward along the axis of the mandibular hinge by the cervical fascia. The anterior counterpart of the mandible is substituted for in a vertical growth pattern. The results are increased overjet with open bite and CII type of molar relationship, this can be explained by the muscle feedback system and the tissue stretch theory (Martinez-Mihi et al., 2014).

CHAPTER III: MATERIALS AND METHODS

3.1 Ethical Approval

The study was registered at the Research and Innovation Center of Riyadh Elm University, Riyadh, Saudi Arabia, with registration number “FPGRP/2023/721/974”. Moreover, it has been reviewed by the Institutional Review Board (IRB) “FPGRP/2023/721/974/882”. (Appendix I)

In addition, an IRB was obtained from Sultan Bin Abdulaziz Humanitarian City (SBAHC) with IRB no. 103-2023-IRB. (Appendix II)

3.2 Informed Consent

A parent or caregiver signed an informed consent form after the study aim was explained to them. (Appendix III)

3.3 Intra-examiner Reliability

The intra-rater reliability was assessed by one researcher two times using Cohen's kappa statistic. A total of 13 agreements were observed, representing 92.86% of the observations. This was significantly higher than the 8.7 agreements expected by chance (62.24% of the observations). The kappa coefficient was 0.811, indicating a substantial level of agreement between the observers. The standard error of kappa was 0.179, and the 95% confidence interval ranged from 0.460 to 1.000. a weighted kappa was also calculated to account for the degree of disagreement between the observers. This analysis revealed a weighted kappa of 0.857, further supporting the high level of agreement between the observers. These findings suggest that the observers demonstrated a high level of consistency in their assessments, with only minor discrepancies in their classifications.

3.4 Study Design and Setting

This study is a cross-sectional study with clinical examination. It took place at Sultan Bin Abdulaziz Humanitarian City and Children with Disability Association Center in Riyadh, Saudi Arabia.

3.5 Sampling and Sample Size Estimation

The sample size was calculated based on the following formula: $n=(z_{\alpha}^2\, p \cdot q)/E^2$ Where Zα = 1.96; p = 86% (prevalence of malocclusion in cerebral palsy patients based on a previous study reported by (Medeiros Rodrigues Cardoso et al., 2020); q = 14 (100 − 86); Confidence interval = 95%; Level of significance = 5%; E (allowable error) = 5%.

The sample size estimation yielded 185 patients to be part of the study. Considering the study would be carried out on a representative sample, it was reasonable to select 15 more patients, expecting a decline rate of 8-10% of those invited to participate in the study (e.g., due to a change of their circumstances). Thus, making a final sample size of 200 patients was considered in this study. Convenience sampling methodology was employed to select the study sample.

3.6 Sample Selection Criteria

3.6.1 Study Group (CP Group):

It involved a total of (n=231) children with a different subtype of spastic CP who were enrolled in two rehabilitation institutions and were included in the study based on inclusion criteria.

The following criteria were used to select participants:

3.6.2 Inclusion Criteria:

- A patient diagnosed with cerebral palsy.

- Age range older than 4 years and less than 15 years.
- Never had orthodontic treatment.
- For primary dentition: full set of dentitions
- For mixed dentition, full eruption, either primary or permanent, of these teeth include: (central, lateral, canine, and 1st molar).
- For permanent dentition: fully eruption permanent teeth include: (central, lateral, canine, and 1st molar).
- Free from extensive caries.

3.6.3 Exclusion Criteria:

- Patients are diagnosed with any other syndrome.
- Age range less than 4 years and older than 15 years.
- Had previous orthodontic treatment.
- Extensive caries on the teeth that affect the mesio-distal or occluso-gingival dimension, therefore affecting the occlusal characteristics.
- Missing teeth due to previous extraction.
- Partially eruption of these teeth includes: (central, lateral, canine, and 1st molar).

3.7 The Study Protocol

3.7.1 Data collection:

- Information was obtained from the patients' file: (Appendix IV)

- Type of CP condition and degree of impairment.
- Age and gender of the child.

- Association problems such as intellectual disability, epilepsy, hearing problems, vision problems, speaking problems, swallowing problems, and increased saliva.

- Answers were provided by caregivers to the questionnaire: (Appendix IV)

- Type of the birth of the child (normal or C-section).
- Duration of the pregnancy (preterm or full term).
- Do the parents share a consanguineous relationship?
- If the child has twins or not? status of the twins?

3.7.2 Study Tools:

- Disposable mouth mirror.
- Ruler (numbering starting with zero).
- Light source

3.7.3 Clinical Examinations & Operational Definition:

- The researcher conducted oral clinical examinations while teeth were in centric occlusion with records of the following: (Appendix IV)

- Type of the dentition: primary, mixed, or permanent.
- The primary molar and canine relationship, overjet, and overbite were assessed using Foster and Hamilton criteria with the teeth in centric occlusion (Kumar and Gurunathan, 2019; Vegesna et al., 2014).

Primary molar relationship (terminal plane): the relationship of the maxillary and mandibular second primary molars in the vertical plane.

Flush terminal plane: the distal surfaces of upper and lower primary second molars are in one line with each other when the primary teeth are in occlusion.

Distal step: the distal surface of the lower primary second molar is distal to the distal surface of the primary upper second molar in occlusion.

Mesial step: the distal surface of the lower primary second molar is mesial to the distal surface of the upper primary second molar in occlusion**.**

Primary canine relationship:

Class I: the cusp tip of the upper primary canine is in the same vertical plane as the distal surface of the lower primary canine.

Class II: the cusp tip of the upper primary canine tooth is mesial to the distal surface of the lower primary canine.

Class III: the cusp tip of the upper primary canine is distal to the distal surface of the lower primary canine.

Overjet and overbite measure for primary incisor : (Onyeaso and Sote, 2002)

Overjet: measured in centric occlusion on the greatest distance between the incisal edge of the maxillary and mandibular primary incisors in the horizontal plane:

- Normal: if overjet was less or equal to 2 mm.
- Increased: overjet greater than 2 mm.
- Reversed: if there is an anterior crossbite.

Overbite: This is the vertical measurement of anterior maxillary teeth covering the mandibular anterior teeth in the normal occlusal position of the jaws.

- Normal overbite: when the incisal tips of the primary lower central incisal contact the palatal surfaces of the upper primary central incisors.
- Deep bite: when the incisal tips of the primary lower central incisors touch the palate mucosa.
- Open bite: when the incisal tips of the primary lower central incisors stay below the level of the incisal tips of the upper primary central incisors.
- Edge-to-edge: This is equal to 0 mm and is obtained when the incisal edges of the upper and lower primary central incisors meet in an edge-to-edge position.

Permanent molar relationship between right and left sides recorded according to Angle's Classification: (Fatani et al., 2019)

Class I: Mesiobuccal cusp of the maxillary first molar occludes with the mesiobuccal groove of the mandibular first molar in maximum intercuspation.

Class II: Mesiobuccal cusp of the maxillary first molar occludes mesial to the mesiobuccal groove of the mandibular first molar in maximum intercuspation.

Class III: Mesiobuccal cusp of the maxillary first molar occludes distal to the mesiobuccal groove of the mandibular first molar in maximum intercuspation.

Permanent canine relationship between right and left sides, according to Angle's Classification: (Fatani et al., 2019)

Class I: Maxillary canine cusp tip occludes with the embrasure between the mandibular canine and first premolar.

Class II: Maxillary canine cusp tip occludes mesial to the embrasure between the mandibular canine and first premolar.

Class III: Maxillary canine cusp tip occludes distal to the embrasure between the mandibular canine and first premolar.

Presence of anterior or posterior crossbite: (Fatani et al., 2019)

Anterior cross-bite: is a lingual positioning of the anterior maxillary teeth to the mandibular anterior teeth.

Posterior cross-bite: is a transversal relationship between the upper and lower jaws, where the upper buccal cusps occlude the fossa of the lower teeth.

Overjet and overbite measure for permanent incisor: (Proffit et al., 2019)

Overjet: defined as the horizontal overlap of the incisors. Normally the incisors are in contact, with the upper incisors ahead of the lower by only the thickness of their incisal edges (i.e., overjet of 2 to 3 mm is the normal relationship). If the lower incisors are in front of the upper incisors, the condition is called reverse overjet.

Overbite: defined as the vertical overlap of the incisors. Normally, the lower incisal edges contact the lingual surface of the upper incisors at or above the cingulum.

- Normal: overbite between 1-2 mm.
- Deep bite: overbite more than 2 mm.
- Edge-to-edge relationship: overbite equal to 0.

- Anterior open bite: no vertical overlap and vertical separation.

Incisor Relationship: (Abu Alhaija and Qudeimat, 2003)

Class I: The lower incisor edges occlude with or lie immediately below the cingulum plateau of the upper central incisors.

Class II Division 1: The lower incisor edges lie posterior to the cingulum plateau of the upper incisors, where the upper incisors are proclined. The overjet is increased.

Class II Division 2: The lower incisor edges lie posterior to the cingulum plateau of the upper incisors, where the upper central incisors are retroclined. The overjet is usually minimal but may be increased.

Class III: The lower incisor edges lie anterior to the cingulum plateau of the upper incisors. The overjet is reduced or reversed.

Oral habits determination: (Rahmawati et al., 2020)

The children's oral cavities were examined to observe the clinical symptoms that might lead to oral habits. Their parents were asked to fill out the questionnaire as supporting data to determine whether there was a oral habit.

The questionnaire and the children's data were recorded, as well as the presence or absence of oral habits such as mouth breathing, thumb/digit sucking, nail-biting, bruxism, and lip sucking/ biting. (Appendix IV)

Oral breathing determination: (Bakarčić et al., 2015)

Shown by water vapor condensing on the surface of a mirror placed outside the mouth.

3.8 Statistical Analysis

Data were analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 27 (SPSS Inc., Chicago, IL). Numerical data were described as mean, standard deviation, and range. Categorical data were described as numbers and percentages. Comparisons between categorical variables were performed using the chi-square test. A p-value less than or equal to 0.05 was considered statistically significant. All tests were two-tailed.

CHAPTER IV: RESULTS

- **Demographic Characteristics:**

Age & Gender Distribution:

A total of (n=231) participants, ranging in age from 4 to 15 years (mean ± SD = 8.5 ± 3.3 years), were included in the analysis. Among the participants, 48.1% were female (111), and 51.9% were male (120). The gender distribution of the study participants is shown in (Table 1).

Table 1: Gender distribution of the study participants

Variable	Gender	
	N	%
Male	120	51.9
Female	111	48.1
Total	231	100.0

Type of Birth & Maturity:

Regarding the type of birth, 50.6% were born through a normal delivery, while 49.4% were born via cesarean section. In terms of maturity at birth, 29.9% were born full-term, and 70.1% were born preterm. The type of birth and maturity of the study participants is shown in (Table 2).

Table 2: Type of birth of and maturity the study participants

	N	%
Normal delivery	117	50.6
C-section	114	49.4
Full term	69	29.9
Preterm	162	70.1

Degree of Impairment:

Among the participants, all of them have spastic type of CP with different degree of impairment. Most of the participants (n=123) were diagnosed with diplegia (53.2%) followed by quadriplegia

93 (40.3%) and (n=15) participants (6.5%) had hemiplegia. None of the participants diagnosed with monoplegia degree. The degree of impairment of the study participants is shown in (Table 3).

Table 3: Degree of impairment among the participants		
	N	%
Diplegia	123	53.2
Quadriplegia	93	40.3
Hemiplegia	15	6.5
Total	231	100.0

Consanguineous Marriages:

There are approximately 41.6% of mothers and fathers who had consanguineous marriage whereas 58.4% are not. The distribution of the mothers and fathers' status of marriages shown in (Table 4).

Table 4: Consanguineous Marriages		
	N	%
Yes	96	41.6
No	135	58.4
Total	231	100.0

Twins Availability:

Furthermore, the sample included (n=33) twins, 72.7% of whom had cerebral palsy, while 27.3% were healthy as shown in (Table 5).

Table 5: Twins with CP(N=33)		
	N	%
Yes	24	72.7
No	9	27.3
Total	33	100.0

- **Associated Problems:**

Among the participants, (n=165) (71.4%) had vision problems, (n=162) (70.1%) experienced speaking problems, and (n=129) (55.8%) had intellectual disability. Additionally, (n=81) (35.1%) individuals reported increased saliva, (n=57) (24.7%) had swallowing problems, (n=48) (20.8%) experienced epilepsy, and (n=21) (9.1%) reported hearing problems. Associated Problems is shown in (Table 6).

Table 6: Associated Problems in participants with Cerebral Palsy

	N	%
Vision Problems*	165	71.4
Speaking Problems*	162	70.1
Intellectual Disability*	129	55.8
Increased Saliva*	81	35.1
Swallowing Problems*	57	24.7
Epilepsy*	48	20.8
Hearing Problems*	21	9.1

*Participants presented by more than one associated problem at the same time

- **Dental Characteristics related all CP sample:**

The distribution of dentition types among the participants showed that (n=114) (49.4%) had mixed dentition, (n=690 (29.9%) had primary dentition, and (n=48) (20.8%) had permanent dentition.

The presence of anterior crossbite was reported in (n=36) (15.6%) participants, while (n=195) (84.4%) did not have this condition. Similarly, posterior crossbite was present in (n=21) (9.1%) participants, whereas (n=210) (90.9%) did not exhibit this characteristic. Dentition types and presence of any crossbite are shown in (Table 7).

Table 7: Dental Characteristics; Type of dentition and Presence of Crossbite

Type of dentition	N	%
Mixed	114	49.4
Primary	69	29.9
Permanent	48	20.8

Anterior Crossbite (No)	195	84.4
Anterior Crossbite (Yes)	36	15.6
Posterior Crossbite (No)	210	90.9
Posterior Crossbite (Yes)	21	9.1

Regarding overjet, out of the total cases analyzed, the majority of cases showed increased overjet, with (n=123) cases (53.2%) falling into this category. On the other hand, normal overjet was observed in (n=75) cases (32.5%), indicating a normal horizontal overlap of the incisors, while (n=27) cases (11.7%) exhibited reverse overjet, where the lower incisors protrude beyond the upper incisors.

In terms of overbite, most of cases (57.4%) were classified as deep bite, where the upper incisors excessively overlap the lower incisors. Normal overbite, characterized by a normal vertical overlap of the incisors, was observed in (n=63) cases (30.9%). Additionally, (n=18) cases (8.8%) were classified as open bite, where there is no overlap between the upper and lower incisor.

A total of (n=6) cases (2.6%) were classified as edge-to-edge bite, indicating that the upper and lower incisors meet directly on the edge (Table 8).

Table 8: Dental Characteristics: Overjet & Overbite

	N	%
Increased overjet	123	53.2
Normal overjet	75	32.5
Reverse overjet	27	11.7
Deep bite	117	57.4
Normal bite	63	30.9
Open bite	18	8.8
Edge to edge	6	2.9

- **Oral Habits:**

Regarding oral habits, most of the participants had oral breathing (n=171) (74%) while (n=60) (26%) displayed exclusively nasal breathing.

Thumb sucking was reported by (n=36) (15.6%) participants, tongue thrust by (n=93) (40.3%), lip biting by (n=39) (16.9%), nail biting by (n=54) (23.4%), and bruxism by (n=81) (35.1%) participants (Table 9).

Table 9: Oral Habits

	N	%
Oral breathing*	171	74
Tongue thrust*	93	40.3
Bruxism*	81	35.1
Nail biting*	54	23.4
Lip biting*	39	16.9
Thumb sucking*	36	15.6

*Participants had more than one at the same time

- **Occlusal Relationship Among Different Dentition:**

Primary Dentition (n=69):

Primary Molars (Right and Left):

The most prevalent occlusion pattern is " Mesial Step" accounting for 87% of cases for both right and left primary molars. The "Flush terminal plane" occlusion pattern is observed in 8.7% of cases for both right and left primary molars. The " Distal Step" occlusion pattern is the least common, present in only 4.3% of cases for both right and left primary molars.

Primary Canines (Right and Left):

The "CI" occlusion pattern is the most prevalent, observed in 63.6% of cases for both right and left primary canines. The "CII" occlusion pattern occurs in 18.2% of cases for both right and left primary canines. The "CIII" occlusion pattern is also present in 18.2% of cases for both right and left primary canines.

Incisor Relation:

The "CI" occlusion pattern is observed in 43.5% of cases. The "CII DIV 1" occlusion pattern accounts for 34.8% of cases. The "CII DIV 2" occlusion pattern is observed in 4.3% of cases. The "CIII" occlusion pattern occurs in 17.4% of cases. The explanations for primary dentition are shown in (Table 10).

Table 10: Primary Dentition			
		No	**%**
Primary Molar Right(n=99)	Distal Step	3	4.3
	Flush Terminal	6	8.7
	Mesial Step	60	87
Primary Molar Left(n=99)	Distal Step	3	4.3
	Flush Terminal	6	8.7
	Mesial Step	60	87
Primary Canine Right(n=153)	CI	42	63.6
	CII	12	18.2
	CIII	12	18.2
Primary Canine Left(n=153)	CI	42	63.6
	CII	12	18.2
	CIII	12	18.2
Incisor Relation(n=231)	CI	30	43.5
	CII DIV 1	24	34.8
	CII DIV 2	3	4.3
	CIII	12	17.4

Mixed Dentition(n=114):

Primary Molars relationship (Right and Left):

There were similar patterns of relationship between the right and left primary molars. The majority of primary molars in mixed dentition exhibit the "Mesial Step" occlusion pattern, which accounts for 70% of the observations. The "Flush terminal plane" occlusion pattern is less common, representing 30% of the observations.

Permanent Molars (Right and Left):

Right and left permanent molars relationship showed slightly different patterns in (n=3) cases. The "CI" occlusion pattern is the most prevalent, observed in 71.4% (Right) and 75% (Left) of cases. The "CII" occlusion pattern is the second most common, found in 21.4% (Right) and 17.9% (Left) of cases. The "CIII" occlusion pattern is the least frequent, occurring in 7.1% in both Right and Left of cases.

Primary Canines (Right and Left):

The "CI" occlusion pattern is the most prevalent, observed in 72.4% in both right and left of cases. The "CII" occlusion pattern is the second most common, found in 17.2% in both Right and Left of cases. The "CIII" occlusion pattern occurs in 10.3% in both right and left of cases.

Permanent Canines (Right and Left):

The "CII" occlusion pattern is the most present in 50% in both right and left of cases. The "CI" occlusion pattern is observed in 33.3% in both right and left of cases. The "CIII" occlusion pattern occurs in 16.7% in both right and left of cases.

Incisor Relation:

The "CII DIV 1" occlusion pattern is the most common prevalent, found in 55.3% of cases. The "CI" occlusion pattern is the second most common, observed in 34.2% of cases. The "CII DIV 2" occlusion pattern occurs in 2.6% of cases. The "CIII" occlusion pattern is present in 7.9% of cases. The mixed dentition is shown in (Table 11).

Table 11: Mixed Dentition		**Mixed**	
		No	**%**
Primary Molar Right(n=99)	Flush Terminal	9	30
	Mesial Step	21	70
Primary Molar Left(n=99)	Flush Terminal	9	30
	Mesial Step	21	70

Permanent Molar Right(n=132)	CI	60	71.4
	CII	18	21.4
	CIII	6	7.1
Permanent Molar Left(n=132)	CI	63	75
	CII	15	17.9
	CIII	6	7.1
Primary Canine Right(n=153)	CI	63	72.4
	CII	15	17.2
	CIII	9	10.3
Primary Canine Left(n=153)	CI	63	72.4
	CII	15	17.2
	CIII	9	10.3
Permanent Canine Right(n=57)	CI	6	33.3
	CII	9	50
	CIII	3	16.7
Permanent Canine Left(n=57)	CI	6	33.3
	CII	9	50
	CIII	3	16.7
Incisor Relation(n=231)	CI	39	34.2
	CII DIV 1	63	55.3
	CII DIV 2	3	2.6
	CIII	9	7.9

Permanent Dentition(n=48):

Permanent Molars (Right and Left):

The most prevalent occlusion pattern is "CI," observed in 43.8% of cases for both right and left molars. The "CII" occlusion pattern accounts for 31.3% of cases for both right and left molars. The "CIII" occlusion pattern is present in 25% of cases for both right and left molars.

Permanent Canines (Right and Left):

The "CI" occlusion pattern is observed in 38.5% of cases for both right and left canines. The "CII" occlusion pattern occurs in 30.8% of cases for both right and left canines. The "CIII" occlusion pattern is also present in 30.8% of cases for both right and left canines.

Incisor Relation:

The most prevalent occlusion pattern is "CII DIV 1," accounting for 81.3% of cases. The "CIII" occlusion pattern occurs in 12.5% of cases. The "CII DIV 2" occlusion pattern is observed in 6.3% of cases. A list of permanent dentition can be found in (Table12).

Table 12: Permanent Dentition			
		No	**%**
Permanent Molar Right(n=132)	CI	21	43.8
	CII	15	31.3
	CIII	12	25
Permanent Molar Left(n=132)	CI	21	43.8
	CII	15	31.3
	CIII	12	25
Permanent Canine Right(n=57)	CI	15	38.5
	CII	12	30.8
	CIII	12	30.8
Permanent Canine Left(n=57)	CI	15	38.5
	CII	12	30.8
	CIII	12	30.8
Incisor Relation(n=231)	CII DIV 1	39	81.3
	CII DIV 2	3	6.3
	CIII	6	12.5

Different Sub-types of Spastic Cerebral Palsy and Related Factors:

I. Demographics and Associated Problems:

Gender Distribution:

The gender distribution (Table 13) among CP types showed that diplegia had (n=63) cases (51.2%) of males and (n=60) cases (48.8%) of females. Hemiplegia had (n=6) cases (40.0%) of males and (n=9) cases (60.0%) of females. Quadriplegia had (n=51) cases (54.8%) of males and (n=42) cases

(45.2%) of females. **No statistically significant differences** were found in gender distribution among the CP types (p = 0.550).

Mode of Delivery:

Regarding the mode of delivery (Table 13), diplegia had (n=66) cases (53.7%) delivered normally and (n=57) cases (46.3%) delivered via C-section. Hemiplegia had (n=6) cases (40.0%) delivered normally and (n=9) cases (60.0%) delivered via C-section. Quadriplegia had (n=45) cases (48.4%) delivered normally and (n=48) cases (51.6%) delivered via C-section. **No significant differences** were found in CP types based on the mode of delivery (p= 0.518).

Maturity at Birth:

The distribution of CP types based on maturity at birth (Table 13) revealed that diplegia had (n=39) cases (31.7%) of full-term infants and (n=84) cases (68.3%) of preterm infants. Hemiplegia had (n=9) cases (60.0%) of full-term infants and (n=6) cases (40.0%) of preterm infants. Quadriplegia had (n=21) cases (22.6%) of full-term infants and (n=72) cases (77.4%) of preterm infants. There **was a statistically significant** association between maturity at birth and CP types (p= 0.011). Preterm infants were more commonly affected by CP in general and specifically in the quadriplegia group, pairwise post-hoc comparisons (Table14) revealed that preterm was lower in diplegia than quadriplegia and hemiplegia.

Presence of Consanguineous Marriages:

Regarding the presence of consanguineous marriages (Table 13), diplegia had (n=48) cases (39.0%) with consanguineous marriages by the parents and (n=75) cases (61.0%) without. Hemiplegia had (n=6) cases (40.0%) with consanguineous marriages and (n=9) cases (60.0%) without. Quadriplegia had (n=42) cases (45.2%) with consanguineous marriages and (n=51) cases

(54.8%) without. **No significant differences** were found in CP types based on the presence of consanguineous marriages. (p = 0.658).

Presence of Twins:

Among the participants total of (n=33) of CP had a twin (Table 13) with (n=24) of them affected by CP on the other twin. (n=18) cases of diplegia subtype CP (100.0%) had a twin affected by CP with. In the hemiplegia group, (n=3) cases (50.0%) had a twin with CP, and in the quadriplegia group, (n=6) cases (66.7%) had a twin with CP. The presence of twins affected by CP was **significantly associated with diplegia** (p < 0.001). Pairwise post-hoc comparisons (Table14) between CP subtypes revealed significant difference between diplegia and hemiplegia (p = 0.001) and diplegia and quadriplegia (p < 0.001) in terms of twin status.

Interestingly, the presence of a twin with CP demonstrated a strong association with the CP types. The diplegia group had a higher proportion of twins with CP compared to the other two groups, indicating a potential influence of twin status on the specific CP type.

Intellectual Disability:

Among the participants, (n=54) cases (43.9%) with diplegia did not have ID (Table 13), while (n=69) cases (56.1%) did. In the hemiplegia group, (n=3) cases (20.0%) did not have ID, while (n=12) cases (80.0%) did. For quadriplegia, (n=450 cases (48.4%) did not have ID, and (n=48) cases (51.6%) did. **No statistically significant differences** were found in the distribution of ID among CP subtypes (p = 0.121).

Epilepsy:

Regarding epilepsy (Table 13), (n=99) cases (80.5%) with diplegia did not have epilepsy, while (n=24) cases (19.5%) did. In the hemiplegia group, (n=12) cases (80.0%) did not have epilepsy, and (n=3) cases (20.0%) did. For quadriplegia, (n=72) cases (77.4%) did not have epilepsy, and

(n=21) cases (22.6%) did. **No statistically significant differences** were observed in the distribution of epilepsy among CP subtypes (p = 0.857).

Hearing Problems:

The analysis showed that (n=111) cases (90.2%) with diplegia did not have hearing problems (Table 13), while (n=12) cases (9.8%) did. In the hemiplegia group, all (n=15) cases (100.0%) did not have hearing problems. For quadriplegia, (n=84) cases (90.3%) did not have hearing problems, and (n=9) cases (9.7%) did. **No statistically significant differences** were found in the distribution of hearing problems among CP subtypes (p = 0.448).

Vision Problems:

Among the participants, (n=36) cases (29.3%) with diplegia did not have vision problems (Table 13), while (n=87) cases (70.7%) did. In the hemiplegia group, (n=6) cases (40.0%) did not have vision problems, and (n=9) cases (60.0%) did. For quadriplegia, (n=24) cases (25.8%) did not have vision problems, and (n=69) cases (74.2%) did. **No statistically significant** differences were observed in the distribution of vision problems among CP subtypes (p = 0.512).

Speaking Problems:

In the diplegia group, (n=45) cases (36.6%) did not have speaking problems (Table 13), while (n=78) cases (63.4%) did. Regarding hemiplegia, (n=6) cases (40.0%) did not have speaking problems, and (n=9) cases (60.0%) did. For quadriplegia, (n=18) cases (19.4%) did not have speaking problems, and (n=75) cases (80.6%) did. **A statistically significant association** was found between speaking problems and CP subtypes (p = 0.016). Pairwise post-hoc comparisons (Table 14) revealed significant differences between diplegia and quadriplegia.

Increased Saliva:

The presence of increased saliva (Table 13) showed **a statistically significant** association with cerebral palsy subtypes ($p < 0.001$). Specifically, among participants with diplegia, (n=30) cases (24.4%) had increased saliva, while among those with hemiplegia, (n=3) cases (20.0%) had increased saliva, and among those with quadriplegia, (n=48) cases (51.6%) had increased saliva. The quadriplegia group is **statistically significant** from the other two groups. Pairwise post-hoc comparisons (Table14) between CP subtypes revealed significant difference between diplegia and quadriplegia ($p<0.001$) and hemiplegia with quadriplegia ($p \leq 0.023$).

Swallowing Problems:

No statistically significant differences were found among CP subtypes for the distribution of swallowing problems ($p = 0.100$) (Table 13).

Table 13: Distribution of Characteristics and Associated Factors in Different Types of Cerebral Palsy

		Diplegia	**Hemiplegia**	**Quadriplegia**	
		n=123(%)	**n=15(%)**	**n=93(%)**	**p value**
Gender	Female	60(48.8)	9(60.0)	42(45.2)	0.550
	Male	63(51.2)	6(40.0)	51(54.8)	
Mode of delivery	C-section	57(46.3)	9(60.0)	48(51.6)	0.518
	Normal	66(53.7)	6(40.0)	45(48.4)	
Maturity	Full	39(31.7)	9(60.0)	21(22.6)	**0.011**
	Preterm	84(68.3)	6(40.0) *	72(77.4)	
Consanguineous Marriages	No	75(61.0)	9(60.0)	51(54.8)	0.658
	Yes	48(39.0)	6(40.0)	42(45.2)	
Twins	No	105(85.4)	9(60.0)	84(90.3)	**0.008**
	Yes	18(14.6)	6(40.0) *	9(9.7)	
Twins with CP	No	0(.0)	3(50.0)	6(66.7)	**<0.001**
	Yes	18(100.0) *	3(50.0)	3(33.3)	
Intellectual Disability	No	54(43.9)	3(20.0)	45(48.4)	0.121
	Yes	69(56.1)	12(80.0)	48(51.6)	

Epilepsy	No	99(80.5)	12(80.0)	72(77.4)	0.857
	Yes	24(19.5)	3(20.0)	21(22.6)	
Hearing Problem	No	111(90.2)	15(100.0)	84(90.3)	0.448
	Yes	12(9.8)	0(.0)	9(9.7)	
Vision Problem	No	36(29.3)	6(40.0)	24(25.8)	0.512
	Yes	87(70.7)	9(60.0)	69(74.2)	
Speaking Problem	No	45(36.6)	6(40.0)	18(19.4)	**0.016**
	Yes	78(63.4) [a]	9(60.0)	75(80.6) [a]	
Swallowing Problem	No	99(80.5)	9(60.0)	66(71.0)	0.100
	Yes	24(19.5)	6(40.0)	27(29.0)	
Increased Saliva	No	93(75.6)	12(80.0)	45(48.4)	**<0.001**
	Yes	30(24.4)	3(20.0)	48(51.6) *	

p<0.05 is statistically significant, analysis done by Chi square test, *: this group is statistically significant from the other two groups, similar lower-case letters are statistically significant

Table 14: Pairwise/ post-hoc comparisons analysis of significant factors

Pairwise Comparisons	Diplegia & Hemiplegia	Diplegia& Quadriplegia	Hemiplegia& Quadriplegia
Maturity	0.030	0.138	0.003
There is Twins	0.014	0.275	0.002
Twin With CP	0.001	<0.001	0.519
Speaking Problem	0.796	0.006	0.074
Increased Saliva	0.707	<0.001	0.023

p<0.05 is statistically significant

II. Occlusal Relationship:

- **Primary Dentation:**

Primary Molar relationship (Right & Left):

Both sides followed the similar patterns for molar relationship. It is observed that "Mesial Step" found in diplegia by 88.0%, 100.0% of hemiplegia and 80.0% of Quadriplegia. Flush terminal plan relation was exhibited in just diplegia by 11.8% while no individuals with hemiplegia and

quadriplegia displayed this relation. 20% of individuals with quadriplegia showed "Distal Step" relation.

Primary Canine Relationship (Right & Left):

For both primary canine right and left, it is observed that "CI" found in diplegia by 70.0%, 100.0% of hemiplegia and 25.0% in quadriplegia. Moreover, 23.5% of individuals with diplegia had the "CII" relation and none in other types. The "CIII" characteristic was present in diplegia by 5.9% and quadriplegia by 75.0%

Incisor Relation:

Among individuals with diplegia, 47.1% exhibited the CI, 41.2% had CII DIV 1, 5.9% had CII DIV 2 and 5.9% displayed the CIII relationship. Individuals with hemiplegia (100.0%) did not show any specific incisor relation rather than CII DIV 1. For participants with quadriplegia, 40.0% had CI relation and 60.0% showed CIII incisor relation (Table 15).

Table 15: Primary Dentition Relationship		**Diplegia**	**Hemiplegia**	**Quadriplegia**	
		n(%)	**n(%)**	**n(%)**	**p value**
Primary Molar Right	Distal Step	0(.0)	0(.0)	3(20.0)	NA
	Flush Terminal	6(11.8)	0(.0)	0(.0)	
	Mesial Step	45(88.2)	3(100.0)	12(80.0)	
Primary Molar Left	Distal Step	0(.0)	0(.0)	3(20.0)	NA
	Flush Terminal	6(11.8)	0(.0)	0(.0)	
	Mesial Step	45(88.2)	3(100.0)	12(80.0)	
Primary Canine Right	CI	36(70.6)	3(100.0)	3(25.0)	NA
	CII	12(23.5)	0(.0)	0(.0)	
	CIII	3(5.9)	0(.0)	9(75.0)	
Primary Canine Left	CI	36(70.6)	3(100.0)	3(25.0)	NA
	CII	12(23.5)	0(.0)	0(.0)	
	CIII	3(5.9)	0(.0)	9(75.0)	
Incisor Relation	CI	24(47.1)	0(.0)	6(40.0)	NA
	CII DIV 1	21(41.2)	3(100.0)	0(.0)	

	CII DIV 2	3(5.9)	0(.0)	0(.0)	
	CIII	3(5.9)	0(.0)	9(60.0)	

NA: not applicable as violation of assumption of Chi-square test

- **Mixed Dentition:**

Primary Molar relationship (Right & Left):

Both sides followed the similar patterns for molar relationship with **no significant differences** across different subtypes of spastic CP. In both sides, the majority of individuals with diplegia (80.0%), and quadriplegia (60.0%) had the mesial step terminal plane. Flush terminal relation was found in 20.0% in diplegia and 40.0% in quadriplegia, while no individuals with hemiplegia displayed both types. The non-significant p values (e.g., p = 0.427 for Primary Molar R&L).

Permanent Molar relationship (Right & Left):

There is a slight difference between both sides. CI molar relationship for the right side was present in 71.4% of individuals with diplegia, 100.0% of individuals with hemiplegia, and 63.6% of individuals with Quadriplegia. Moreover, CI molar relationship for the left side was observed in 71.4% of individuals with Diplegia, 100.0% of individuals with Hemiplegia, and 72.7% of individuals. The CII relation in right side was seen in 21.4% of individuals with diplegia and 27.3% of quadriplegia. for the CII in the left side, the difference was showed in the quadriplegia by 18.2%. while non-individuals with hemiplegia showed CII relation. CIII relationship was observed similarity in both sides for diplegia (7.1%) and quadriplegia (9.1%).

Primary Canine Relationship (Right & Left):

For both the primary canine right and left, CI relationship present in 76.9% of individuals with Diplegia, 100.0% of individuals with hemiplegia, and 61.5% of individuals with quadriplegia. Moreover, 23.1% of individuals with diplegia, 15.4% of individuals with quadriplegia while none

with hemiplegia showed this relation. The CIII characteristic was present in 23.1% of individuals with quadriplegia and none in other types.

Permanent Canine Relationship (Right & Left):

For both the permanent canine right and left, 50.0% of individuals with diplegia while none of individuals with hemiplegia and quadriplegia exhibited the CI characteristic. Moreover, 25.0% of individuals with diplegia, 100 % of individuals with quadriplegia had the CII relation. The CIII characteristic was present in 25.0 % of individuals with diplegia and none in other types.

Incisor Relation:

Among individuals with diplegia 42.1% exhibited the CI characteristic, 52.6% had the CII DIV 1 characteristic, and 5.3% displayed the CIII characteristic. Individuals with hemiplegia (100.0%) did not show any specific incisor relation characteristics rather than CII DIV 1 100%. with Quadriplegia showed CI relation in 31.3%, 50.0% had the CII DIV 1, 6.3% had CII DIV 2 and 12.5% exhibited the CIII characteristic (Table 16).

Table 16: Mixed Dentition Relationship					
		Diplegia	**Hemiplegia**	**Quadriplegia**	
		n(%)	**n(%)**	**n(%)**	**p value**
Primary Molar Right	Flush Terminal	3(20.0)	0(.0)	6(40.0)	0.427
	Mesial Step	12(80.0)	0(.0)	9(60.0)	
Primary Molar Left	Flush Terminal	3(20.0)	0(.0)	6(40.0)	0.427
	Mesial Step	12(80.0)	0(.0)	9(60.0)	
Permanent Molar Right	CI	30(71.4)	9(100.0)	21(63.6)	NA
	CII	9(21.4)	0(.0)	9(27.3)	
	CIII	3(7.1)	0(.0)	3(9.1)	
Permanent Molar Left	CI	30(71.4)	9(100.0)	24(72.7)	NA
	CII	9(21.4)	0(.0)	6(18.2)	
	CIII	3(7.1)	0(.0)	3(9.1)	
Primary Canine Right	CI	30(76.9)	9(100.0)	24(61.5)	NA
	CII	9(23.1)	0(.0)	6(15.4)	

	CIII	0(.0)	0(.0)	9(23.1)	
Primary Canine Left	CI	30(76.9)	9(100.0)	24(61.5)	NA
	CII	9(23.1)	0(.0)	6(15.4)	
	CIII	0(.0)	0(.0)	9(23.1)	
Permanent Canine Right	CI	6(50.0)	0(.0)	0(.0)	NA
	CII	3(25.0)	0(.0)	6(100.0)	
	CIII	3(25.0)	0(.0)	0(.0)	
Permanent Canine Left	CI	6(50.0)	0(.0)	0(.0)	NA
	CII	3(25.0)	0(.0)	6(100.0)	
	CIII	3(25.0)	0(.0)	0(.0)	
Incisor Relation	CI	24(42.1)	0(.0)	15(31.3)	NA
	CII DIV 1	30(52.6)	9(100.0)	24(50.0)	
	CII DIV 2	0(.0)	0(.0)	3(6.3)	
	CIII	3(5.3)	0(.0)	6(12.5)	

P<0.05 is statistically significant, analysis done by Chi square test, *: this group is statistically significant from the other two groups, similar lower-case letters are statistically significant

NA: not applicable as violation of assumption of Chi-square test

- **In Permanent dentation:**

Permanent Molar relationship (Right & Left):

For the permanent molar right, 60.0% of individuals with diplegia, 40.0% of individuals with quadriplegia showed CI relation. Additionally, For the permanent molar left, 80.0% of individuals with diplegia, 30.0% of individuals with quadriplegia showed CI relation while none of hemiplegia showed this type of relation. 20.0% of individuals with diplegia and 30.0% of quadriplegia showed CII molar relation on right side. However, CII molar relation on the left side was seen in 40.0% of quadriplegia participants. 100.0% of individuals with hemiplegia showed CII molar relation on both sides. CIII Molar Relationship for both sides showed similarity in 20.0% of diplegia and 30.0% of quadriplegia.

Permanent Canine Relationship (Right & Left):

For both sides followed a similar pattern. 100.0% of hemiplegia, 50.0% of individuals with diplegia and 25% of quadriplegia showed CI molar relationship. CII and CIII relationship were present in 25.0% of individuals with diplegia and 37.0% individuals with quadriplegia.

Incisor Relation:

Among participants with diplegia, 80.0% exhibited the CII DIV I relation and 20.0% displayed the CIII characteristic. Hemiplegia type did not show any specific Incisor Relation characteristics rather than CII DIV 1 by 100.0 %. For individuals with quadriplegia, 20.0% had the CII DIV 1 and 10.0% exhibited the CIII characteristic (Table 17).

Table 17: Permanent Dentition Relationship		**Diplegia**	**Hemiplegia**	**Quadriplegia**	
		n(%)	**n(%)**	**n(%)**	**p value**
Permanent Molar Right	CI	9(60.0)	0(.0)	12(40.0)	NA
	CII	3(20.0)	3(100.0)	9(30.0)	
	CIII	3(20.0)	0(.0)	9(30.0)	
Permanent Molar Left	CI	12(80.0)	0(.0)	9(30.0)	NA
	CII	0(.0)	3(100.0)	12(40.0)	
	CIII	3(20.0)	0(.0)	9(30.0)	
Permanent Canine Right	CI	6(50.0)	3(100.0)	6(25.0)	NA
	CII	3(25.0)	0(.0)	9(37.5)	
	CIII	3(25.0)	0(.0)	9(37.5)	
Permanent Canine Left	CI	6(50.0)	3(100.0)	6(25.0)	NA
	CII	3(25.0)	0(.0)	9(37.5)	
	CIII	3(25.0)	0(.0)	9(37.5)	
Incisor Relation	CII DIV 1	12(80.0)	3(100.0)	24(80.0)	NA
	CII DIV 2	0(.0)	0(.0)	3(10.0)	
	CIII	3(20.0)	0(.0)	3(10.0)	

NA: not applicable as violation of assumption of Chi-square test

Overjet, Overbite Measurements and Crossbite:

Regarding overjet**,** there was **significant differences** among the types (p = 0.001). Increased overjet was the most prevalent pattern among individuals with diplegia (51.2%), hemiplegia (100.0%), and quadriplegia (48.4%). Edge-to-edge overjet was present in a small percentage of

individuals across all types. Normal overjet was observed in individuals with diplegia (39.0%) and quadriplegia (29.0%). Reverse overjet was present in individuals with diplegia (7.3%) and quadriplegia (19.4%).

Concerning overbite, **no statistically significant differences** were found among the types (p = 0.143). Deep bite was the most prevalent overbite pattern among individuals with diplegia (55.3%), hemiplegia (80.0%), and quadriplegia (56.0%). Normal overbite was present in individuals with diplegia (34.2%) and quadriplegia (32.0%). Open bite was found in individuals with diplegia (7.9%), hemiplegia (20.0%), and quadriplegia (8.0%).

In terms of anterior and posterior crossbites, **statistically significant differences** were observed among the types (anterior crossbite, p = 0.026; posterior crossbite, p = 0.001). The majority of individuals with diplegia (87.8%) and hemiplegia (100.0%) did not present with anterior crossbite. However, 22.6% of individuals with quadriplegia showed the presence of anterior crossbite. Similarly, the majority of individuals with diplegia (97.6%) and hemiplegia (80.0%) did not have posterior crossbite, while 16.1% of individuals with quadriplegia exhibited posterior crossbite.

The presence of anterior crossbite showed **significant differences** among the types of cerebral palsy, with diplegia (12.2%) and quadriplegia (22.6%, p = 0.043) having a higher prevalence compared to hemiplegia (0.0%). Similarly, the presence of posterior crossbite was significantly different, with diplegia (2.4%, p = 0.002) and hemiplegia (20.0%, p < 0.001) showing a higher prevalence compared to quadriplegia (16.1%) (Table 18).

Table 18: Comparative Analysis of Overjet, Overbite Measurements and Crossbite among Different Types of Cerebral Palsy

		Diplegia	**Hemiplegia**	**Quadriplegia**	
		n=123(%)	**n=15(%)**	**n=93(%)**	**p value**
Overjet	Edge to edge	3(2.4)	0(.0)	3(3.2)	**0.001**
	Increased overjet	63(51.2)	15(100.0)	45(48.4)	

	Normal overjet	48(39.0)	0(.0)	27(29.0)	
	Reverse overjet	9(7.3)	0(.0)	18(19.4)	
Overbite	Deep bite	63(55.3)	12(80.0)	42(56.0)	0.143
	Edge to edge	3(2.6)	0(.0)	3(4.0)	
	Normal overbite	39(34.2)	0(.0)	24(32.0)	
	Open-bite	9(7.9)	3(20.0)	6(8.0)	
Presence Anterior Crossbite	No	108(87.8)	15(100.0)	72(77.4) *	**0.026**
	Yes	15(12.2)	0(.0)	21(22.6)	
Presence Posterior Crossbite	No	120(97.6) *	12(80.0)	78(83.9)	**0.001**
	Yes	3(2.4)	3(20.0)	15(16.1)	

p<0.05 is statistically significant, analysis done by Chi square test, *: this group is statistically significant from the other two groups, A: all groups are statistically significant from each other's

Table 19: Pairwise/ post hoc comparisons analysis of significant factors

	Diplegia & Hemiplegia	**Diplegia & Quadriplegia**	**Hemiplegia & Quadriplegia**
Overjet	0.005	0.049	0.002
Presence Anterior Crossbite	0.152	0.043	0.040
Presence Posterior Crossbite	0.002	<0.001	0.709

p<0.05 is statistically significant

I. Oral Habits:

In terms of oral breathing (Table 20), the results show **no significant differences** among the types of cerebral palsy. The prevalence of oral breathing was 26.8% in diplegia, 40.0% in hemiplegia, and 22.6% in quadriplegia (p = 0.343).

Regarding thumb sucking, there was **a significant difference** between the types; pairwise comparison revealed that diplegia was significant from quadriplegia (p= 0.009), Diplegia exhibited a lower prevalence compared to quadriplegia (22.6%). However, no significant difference was found between hemiplegia and quadriplegia.

The presence of tongue thrust showed a **significant difference** between the types; pairwise comparison revealed that a significant difference between diplegia and quadriplegia (p= 0.003),

with diplegia having a lower prevalence (31.7%) compared to quadriplegia (51.6%). No significant difference was found between diplegia and hemiplegia or between hemiplegia and quadriplegia.

In terms of lip biting, nail biting, and bruxism, **no significant differences** were observed among the three types of cerebral palsy. The prevalence of these oral habits varied across the types but did not reach statistical significance.

Table 20: Comparative Analysis of Oral Habits in Different Types of Cerebral Palsy

		Diplegia	Hemiplegia	Quadriplegia	
		n=123(%)	n=15(%)	n=93(%)	p value
Oral Breathing	No	33(26.8)	6(40.0)	21(22.6)	0.343
	Yes	90(73.2)	9(60.0)	72(77.4)	
Thumb Sucking	No	111(90.2)	12(80.0)	72(77.4)	**0.032**
	Yes	12(9.8) [a]	3(20.0)	21(22.6) [a]	
Tongue Thrust	No	84(68.3)	9(60.0)	45(48.4)	**0.013**
	Yes	39(31.7) [b]	6(40.0)	48(51.6) [b]	
Lip Biting	No	99(80.5)	12(80.0)	81(87.1)	0.415
	Yes	24(19.5)	3(20.0)	12(12.9)	
Nail Biting	No	96(78.0)	12(80.0)	69(74.2)	0.763
	Yes	27(22.0)	3(20.0)	24(25.8)	
Bruxism	No	81(65.9)	9(60.0)	60(64.5)	0.899
	Yes	42(34.1)	6(40.0)	33(35.5)	

p<0.05 is statistically significant, analysis done by Chi square test, similar lower-case letters are statistically significant from each other's

Table 21: Pairwise/ post hoc comparisons analysis of significant factors

	Diplegia & Hemiplegia	Diplegia & Quadriplegia	Hemiplegia & Quadriplegia
Thumb Sucking	0.229	0.009	1.000
Tongue Thrust	0.518	0.003	0.404

p<0.05 is statistically significant

CHAPTER V: DISCCUSION

5.1 Discussion:

This research is a cross-sectional study aimed to assess the prevalence of malocclusion and oral habits in children and adolescents aged from 4 to 15 years affected by different subtypes of spastic CP including (diplegia, hemiplegia, and quadriplegia). The age is within the range group that was chosen as reported in previous study (Medeiros Rodrigues Cardoso et al., 2020).

A general agreement exists that CP children are more likely to have malocclusions due to abnormal muscle function, but multiple studies disagree on the relationship between any specific type of malocclusion and the type of CP (Koster, 1956; Kanar, 1978).

In this study, the majority of participants with different subtypes of spastic CP showed a mesial step terminal plane based on the primary molar relationship. The findings of our study were similar to those of a study conducted in Egypt, which found that most of spastic CP were mesial step terminal plane relationships by 82.1% in both sides. In the same study, the majority of the sample had spastic CP 83.9%, and quadriplegia accounted for 65.1% of the topographic distribution. El Rouby et al. have also reported that 71.6% of canine relationships, whether they were for primary or permanent dentitions, were CI relationships (El Rouby et al., 2019). Similarly, diplegia and hemiplegia with primary dentition displayed CI canine relationships in our sample; however, 75.0% of quadriplegia showed CIII relationships. Yet, we found a different result for the permanent canine relationship in our study, CI was observed in all hemiplegia samples, half of the diplegia samples, and 25% of the quadriplegia samples. Medeiros et al. conducted a cross-sectional study for 134 children aged 2-18 years diagnosed with CP for malocclusion. The presence of CI canine relationships were detected in 52.5% of their samples (Medeiros Rodrigues Cardoso et al., 2020).

According to de Carvalho et al. a clinical examination was performed on permanent molars to determine the type of occlusion distribution. The study sample consisted of spastic type of CP, and nearly half 46.2% had quadriplegia. It showed that 55.8% of the sample had CII molar relationship (de Carvalho et al., 2011). Our results showed similar outcomes, 100.0% of hemiplegics in permanent molar had a CII relationship, whereas diplegics and quadriplegics showed different results.

According to a study published in 1968, children with spastic type of CP are more likely to have a CII DIV1 malocclusion (Isshiki, 1968). While another study exhibited more CII DIV 2 malocclusion distribution among their sample (Weyman, 1971).

The results of a study conducted by Franklin et al., where they compared the incisor relationship in permanent dentition among CP children with and without mental handicap showed that there was a statistically significant increase in CII DIV I among CP children with intellectual disability (Franklin et al., 1996). We similarly found an increase in CII DIV 1 in permanent dentition for all spastic CP subtypes in our study.

A statistically significant difference was also found regarding the overjet among all sub-types of spastic CP children. Overjet increased in all hemiplegia patients compared with other types. In contrast, Medeiros et al. and Carmagnani et al. found that an increased overjet was seen mostly in quadriplegic patients (Medeiros Rodrigues Cardoso et al., 2020; Carmagnani et al., 2007).

According to a systematic review published in 2020, CP and anterior open bite showed a statistically significant correlation (Bensi et al., 2020). It has been suggested that anterior open bites and Angle's CII relationships may be more common in CP due to disbalances between perioral and intraoral muscles, such as abnormal tongue movements (Bakarčić et al., 2015). A

study conducted by Medeiros et al. found that open bites are the most common finding in subtypes of spastic CP. It was observed in 67.7% of quadriplegia cases, 57.1% in hemiplegia cases, and 42.0% in diplegia cases (Medeiros Rodrigues Cardoso et al., 2020). In our study, we found a small percentage of open bites ranging from 7% to 20% across all subtypes. However, our sample showed deep bites as a more common finding. In another study, 88 children with different subtypes of spastic CP were examined, and they found a significant association between spastic CP and anterior open bite, with 61% of quadriplegia having an open bite (Carmagnani et al., 2007). The present study found 8.0 % of quadriplegia had open bites while 56.0% had deep bites.

In this study, clinical examination showed significant differences between subtypes of spastic CP and posterior crossbite. There were 20.0% of hemiplegia, 16.1% of quaderplegia and 2.4% of diplegia had posterior crossbite. The same comparison was reported by Medeiros et al. they found that 30.0% of quadriplegia, 14.3% of hemeplegia and 14.0% of diplegia had posterior crossbites (Medeiros Rodrigues Cardoso et al., 2020). It has been found that several studies failed to demonstrate an association between CP-related posterior crossbites and control groups (Miamoto et al., 2010; Bakarčić et al., 2015).

Similarly in the current study, anterior crossbite was statistically significant among subtypes of CP with a high proportion of quadriplegia by 22.6%. According to a study conducted by Beldiman et al. 25.3% of spastic children with CP had anterior crossbites. Another study by Oliveira et al. found 3.8% of children with CP had anterior crossbites (Beldiman et al., 2016; Oliveira et al., 2011).

The results of our study showed that there was a high number of children with spastic CP with oral breathing 74% with no statistically significantly different between the subtypes. Multiple studies

have shown that oral breathing is significantly higher in the CP group than in the control group (Almotareb and Al-Shamahy, 2024; Bakarčić et al., 2015).

In the present study, there were significant differences among different subtypes of spastic children with CP who habitually thumb sucking and tongue thrusting. Among all groups, the quadriplegia group has the highest percentage. According to Almotareb et al. CP children have a higher tongue thrust than control children, but thumb sucking habits were not significantly different (Almotareb and Al-Shamahy, 2024). According to Ortega et al., tongue interposition habit increased by 56.2% between 2-6 years of age in the CP group (Ortega et al., 2007).

There is no conclusive evidence regarding bruxism in children with CP, in general, it is thought that CP patients are more likely to experience bruxism because their muscles are more prone to contractions (Tuncer et al., 2023). There were multiple studies showing a statistically significant increase in bruxism in CP compared to control groups (Botti Rodrigues dos Santos et al., 2003; Ortega et al., 2007). The bruxism rate in our study was 35.1% and the variation between subtypes was not statistically significant.

In the CP group, biting objects was more frequent than in the control group. Biting objects habit was a more frequent in CP group than in the control group. A study by Ortega et al. did not find statistically significant differences in biting between age groups, while biting persists into older age groups (Ortega et al., 2007).

In our study, nail biting accounted for 23.4% of sample members, while lip biting accounted for 16.9%, but there was no statistically significant difference between spastic subtypes. Children

diagnosed with a different subtype of spastic CP should be closely followed from early age to timely detect and treat all dental problems.

5.2 Limitations:

- Different sampling groups for spastic CP subtypes.
- In this study, all types of dentitions and a wide age range are included.
- Questionnaires can lead to a recall bias when it comes to reporting parafunctional activities by parents.
- A sudden involuntary movement that occurs in cerebral palsy.

CHAPTER VI: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion:

- Mesial step terminal plane was the most prevalent primary molar relationship observed among all the subtypes of spastic CP.
- The majority of diplegics and hemiplegics had CI canine occlusion relationships in primary dentition, while most quadriplegics had CIII relationships.
- All the hemiplegia samples with permanent dentition showed a CI canine relationship and CII molar relationship.
- There was a CII DIV 1 incisor relationship in all hemiplegia cases in all types of dentitions.
- A significant difference was observed between subtypes of spastic CP and crossbite.
- Overjet categories showed a significant association with different subtypes of spastic CP condition. Increased overjet was found in more than half of diplegia, all in hemiplegia, and nearly half of quadriplegia.
- Tongue thrust and thumb sucking habits showed a significant association with different types of CP; quadriplegia type has the highest tongue thrust habit (51%) and thumb sucking (22%).

6.2 Recommendations:

- Explore the association of malocclusion in different dentitions separately.
- An analysis of the severity of malocclusion-related IQ in CP children.
- Considering the prevalence of malocclusions with the treatment needs of the patient in a future study.
- Examine the malocclusion in different types of CP, including ataxia and dyskinetic CP.
- Equal grouping of the sample.
- Inclusion of all rehabilitation centers in Saudi Arabia in a nationwide study of malocclusions in cerebral palsy.

CHAPTER VII: REFERENCES

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APPENDICES

APPENDIX I: IRB APPROVAL LETTER FROM REU

جامعة رياض العلم
RIYADH ELM UNIVERSITY

Approval Letter by the Institutional Review Board of Riyadh Elm University

Dear Ghadah Al Dossari

The research proposal submitted to the Research Center by you titled "Prevalence of Dental Malocclusion Among Patients with Cerebral Palsy in Riyadh, Saudi Arabia: A Cross-Sectional Study with Clinical Observation" with a registration number FPGRP/2023/721/974 has been reviewed by the Institutional Review Board (IRB) of Riyadh Elm University (REU).

The IRB observed that you have complied with the ethical requirements of the IRB at Riyadh Elm University. Therefore, your research proposal has been approved with the IRB approval number "FPGRP/2023/721/974/882".

This approval is valid for one year starting 07-Jun-2023. If you require more time for your study, please submit a continuation request to the IRB through the research center portal. In case of any changes in the study protocol, adverse events or termination of the study, please report it to the IRB immediately. Also, note that the IRB might audit your research records at any time.

We wish you a successful project.

Best Regards,

Sincerely yours

Dr. Omar Alkadhi BDS,MSc.
Chairman, Institutional Review Board
Riyadh Elm University

Name of Chief Investigator: Ghadah Al Dossari
Name(s) of Co Investigator: Ghadah Al Dossari, ,
Name(s) of Co/Supervisor: Dr. Haneen Alshukairi

المملكة العربية السعودية - ص.ب: ٨٤٨٩١ الرياض ١١٦٨١ - هـاتف: ٩٢٠٠٠٠٨٤٢
Kingdom of Saudi Arabia - P.O.Box 84891 Riyadh 11681 - Tel.: 920000842 - www.riyadh.edu.sa

APPENDIX II: IRB APPROVAL LETTER FROM SBAHC

مدينة سلطان بن عبد العزيز للخدمات الإنسانية
SULTAN BIN ABDULAZIZ HUMANITARIAN CITY

مدينة سلطان بن عبد العزيز للخدمات الإنسانية
SULTAN BIN ABDULAZIZ HUMANITARIAN CITY
لجنة أخلاقيات البحوث الطبية
Institutional Review Board (IRB)

Date: **03 August 2023**
IRB No.: **103-2023-IRB**

To: **Ms. Ghadah Al Dossari**
MSc: "Prevalence of Dental Malocclusion Among Patients with Cerebral Palsy in Riyadh, Saudi Arabia: A Cross-Sectional Study with Clinical Observation"
Riyadh Elm University
E-mail: ghada.dossari@gmail.com

Subject:	Approval for MSc Research No. 99/MSc/2023
Study Title:	"Prevalence of Dental Malocclusion Among Patients with Cerebral Palsy in Riyadh, Saudi Arabia: A Cross-Sectional Study with Clinical Observation"
Study Code:	99/MSc/2023
Date of Approval:	3/8/2023
Date of Expiry:	5/6/2024
Board approval:	All members except the absentees

Dear **Ms. Ghadah Al Dossari,**

Your Project has been approved and you have permission to conduct this study following your submitted documents as follows:

1. Curriculum Vitae for the PI researcher.
2. Letter from the researcher's affiliating Organization/College.
3. Letter from the researcher requesting SBAHC participation in the clinical study.
4. Letter from the researcher's supervisor requesting supervision in the clinical study.
5. Research proposal according to SBAHC IRB Guidelines.
6. SBAHC Informed Consent Template.
7. Research Obligatory Agreement. Available upon completion of the other requirements.

You are required to obey the rules and regulations of the Government of Saudi Arabia, the SBAHC IRB Policies and procedures, and the ICH-GCP guidelines. You have to note that this approval mandates responding to IRB's periodic requests and surveillance results. Drawing your attention to the following:

- Amendment of the project with the required modification to providing a Periodical report for this project especially when study extension is required or expiry before study completion.

APPENDIX II: IRB APPROVAL LETTER FROM SBAHC

- All unforeseen events that might affect the continued ethical acceptability of the project should be reported to the IRB as soon as possible.
- Personal identifying data should only be collected when necessary for research.
- Secondary disclosure of personal identifiable data is not allowed.
- Monitoring: projects may be subject to an audit by the IRB at any time.
- The PI is responsible for the storage and retention of original data pertaining to the project for a minimum period of five (5) years.
- Data should be stored securely so that a few authorized users are permitted access to the database.

The IRB registered with the IRB KACST Registration No. H-01-R-090. It is authorized to conduct the ethical review of clinic studies and operates in accordance with ICH-GCP Guidelines and all applicable national/local and institutional regulations and guidelines which govern Good Clinical Practices.

For Future Correspondence, please quote the project number and project title above and you are requested to keep IRB informed about your study progress and submit project progress report every six (6) months. A final report should be provided upon completion of the study.

Wishing you success in your research project.

Yours sincerely,

Dr. Khalid Al-Rubeaan
Chairman-Institutional Review Board
Sultan Bin Abdulaziz Humanitarian City

مدينة سلطان بن عبد العزيز للخدمات الإنسانية
SULTAN BIN ABDULAZIZ HUMANITARIAN CITY
لجنة أخلاقيات البحوث الطبية
Institutional Review Board (IRB)

APPENDIX III: INFORMED CONSENT

جامعة رياض العلم
RIYADH ELM UNIVERSITY

مركز البحوث
RESEARCH CENTER

إقرار الموافقة على الاشتراك في البحث

- أنت مدعو للمشاركة في هذا البحث العلمي مشكوراً، وعنوانه:

- انتشار سوء اطباق الأسنان بين مرضى الشلل الدماغي في الرياض ، المملكة العربية السعودية – دراسة مقطعيه مع ملاحظة إكلينيكية

- الهدف من البحث :

- تهدف هذه الدراسة إلى تحديد مدى انتشار سوء إطباق الأسنان وعادات الفم السيئة بين مختلف أنواع مرضى الشلل الدماغي في مدينة الرياض - المملكة العربية السعودية.

إسمي : غادة سالم الدوسري ، و سأكون الباحث المسؤول

إذا كنت موافقًا برغبتك على المشاركة في ذا البحث العلمي ، فستكون من ضمن المتطوعين الذين سيشاركون في هذا البحث العلمي

شرح مفصل :

في ذا المستند ، سأقوم بشرح التالي :

- طريقة البحث
- المخاطر المترتبة على المشاركة في هذا البحث
- تكلفة المشاركة في ذا البحث
- الفائدة من البحث
- المبلغ المدفوع للمشاركة
- بيان سرية المعلومات
- معلومات التواصل مع الباحث
- انهاء البحث قبل اكتماله

APPENDIX III: INFORMED CONSENT

شرح مفصل عن البحث

- **طريقة البحث :**

- سوف أقوم بالكشف على اسنان طفلكم و اخذ علاقة تطابق الاسنان في الفك العلوي مع الفك السفلي ، و اكتشاف ان كان هناك أي عادات سيئة مثل التنفس عن طريق الفم او عادة مص الاصبع و غيرها

- **المخاطر المترتبة على المشاركة في هذا البحث :**

- لا توجد مخاطر أي مخاطر في المشاركة في هذا البحث ، و المشارك له كامل الحق في عدم الإجابة عن أي أسئلة ستطرح عليه او الانسحاب في أي وقت دون ادنى مسؤولية عليه ، ولا يوجد أي تاثير سلبي على علاجه

- **تكلفة المشاركة في ذا البحث :**

- لا يوجد أي تكلفة ماديه للمشاركة في هذا البحث ، حيث سيتم توفير العلاجات اللازمة في حال وجود أي تضرر من المشاركة في هذا البحث

- **الفائدة من البحث:**

- الفوائد المرجوة في هذا البحث هي المعرفة لمدى تطابق الاسنان و اكتشاف العادات السيئة المصاحبة لمرضى الشلل الدماغي

- **المبلغ المدفوع للمشاركة :**

- لا يوجد مبلغ مدفوع للمشاركة في هذا البحث

- **بيان سرية المعلومات :**

- المشاركة في هذا البحث لن توثر على خصوصية المشارك و سوف تحفظ سرية البيانات كاملة

APPENDIX III: INFORMED CONSENT

- **معلومات التواصل مع الباحث :**

  - في حالة الاحتياج للتواصل مع احد الباحثين ، هنا معلومات الباحث الرئيسي
  - الاسم : غادة الدوسري
  - رقم الجوال :

- **انهاء البحث قبل اكتماله :**

  - لا يوجد أسباب في انهاء البحث قبل اكتماله

إقرا ر المشاركة في هذا البحث

لقد قرأت مجتويات هذا المستند وتم شرحها لي بالكامل. وقد تمت الإجابة على جميع استفساراتي بوضوح، وقد تم تزويدي بنسخة من هذا المستند. أوافق متطوعاً على المشاركة في هذا البحث العلمي.

- الاسم الكامل : ----------
- التاريخ : ----------
- التوقيع : ----------

هذا القسم يختص بالأطفال المشاركين أو من هم تحت الرعاية :

أوافق على السماح لطفلي أو من هو تحت رعايتي بالمشاركة في هذا البحث العلمي.

- اسم الطفل : ----------
- اسم ولي الامر : ----------
- توقيع ولي الامر : ----------
- اسم الشاهد : (الباحث الرئيسي او غيره) : ----------
- توقيع الشاهد : ----------
- تاويخ هذا الإقرار : ----------

- نسخة للباحث الرئيسي
- نسخة للمشترك
- نسخة لمكتب مركز البحوث في جامعة رياض العلم

المملكة العربية السعودية ص.ب.١٩٨٤٨ ، الرياض ١٨٦١١. هاتف : ٢٤٨٠٠٠٠٢٩

فاكس: ٣٤٨٠٠٠٠٢٩ الموقع : www.riyadh.edu.sa

APPENDIX IV: DATA SHEET

DATA SHEET

Case number (……...)

- File Number :
- Center/ Hospital :
- Date of joining:

❖ **General Information:**

- Gender : Female / Male
- Child age: ……..
- What is the method of delivery ?? (Normal / C-section)
- Term of birth ? (preterm / full term)
- Do the parents share a consanguineous relationship?
- There is a twins of a child ? (yes / no) / status of the twin? (Normal , CP , other)

❖ **Information from the child's record file :**

- Type of CP :
  - Spastic
  - Dyskinetic
  - Ataxia
  - Mixed
- Degree of impairment :
  - Monoplegia
  - Diplegia
  - Quadriplegia
  - Hemiplegia
- Medical condition?
  - Mental retardation
  - Epilepsy
  - Hearing / Vision / Speaking Impairment
  - Swallowing disorder
  - Increased saliva
  - Other ……. …….

DATA SHEET

❖ **Clinical Examination :**

- Type of dentition :
  - Primary dentition
  - Mixed dentition
  - Permanent dentition

- Molar relationship according to Baume Classification: **(Primary dentition)**

Flush terminal plan (R / L) Mesial step (R / L) Distal step (R / L)

- Molar relationship according to Angle's Classification: **(Permanent dentition)**

CI: (R / L) CII (R / L) CIII: (R / L)

- Canine relationship according to Angle's Classification : **(Primary / Permanent)**

CI: (R / L) CII (R / L) CIII: (R / L)

- Incisors Classification **(British Standard institute / BSI) : (Permanent dentition)**

(CI) (CII DIV1) (CII div 2) (CIII)

- **Measurements of overjet and overbite :**
  - Overjet by mm → ……
  - Overbite by (mm and %) → ……
  - Open-bite by mm → ……..

DATA SHEET

- **Presence of any discrepancies :**

1. Presence of posterior crossbite (yes / no)
2. Presence of anterior crossbite (yes / no)

❖ **Oral habits:**

- **Type of breathing :**
  - Nasal
  - Mouth
  - Both

- **There is any oral habits ?? (yes / no)**
  - Thumb / finger sucking
  - Tongue thrust
  - Lip biting
  - Nail biting
  - Bruxism
  - Other …….. ……

ARABIC ABSTRACT

انتشار سوء إطباق الأسنان بين المرضى المصابين بالشلل الدماغي في الرياض، المملكة العربية السعودية: دراسة مقطعية مع الملاحظة السريرية

الأطروحة قدمتها

غادة سالم الدوسري

قسم وقاية الأسنان، شعبة طب أسنان الأطفال

قدمت كأحد متطلبات الحصول على درجة الماجستير في علوم طب الفم والأسنان

إشراف

د. حنين الشقيري

أستاذ مساعد في طب أسنان الأطفال

رئيس قسم وقاية الاسنان

كلية طب الأسنان جامعة رياض العلم

المملكة العربية السعودية

٢٠٢٤م_١٤٤٥هـ

الخلفية: الشلل الدماغي هو مثال على الإعاقة العصبية العضلية التي يتم تعريفها على أنها مجموعة من الاضطرابات الدائمة في تطور الحركة والوضعية التي تؤدي إلى تقييد النشاط وتكون نتيجة لاضطرابات غير تقدمية حدثت في الجنين أو دماغ الرضيع. يكون الأطفال المصابين بالشلل الدماغي من زيادة خطر سوء الإطباق م بسبب نقص التوتر في عضلات الوجه، والتنفس عن طريق الفم، وعادات دفع اللسان، واضطراب البلع.

الهدف: هو تحديد مدى انتشار سوء إطباق الأسنان والعادات الفموية السيئة بين الأنواع الفرعية المختلفة من مرضى الشلل الدماغي التشنجي، بما في ذلك (الشلل المزدوج، والشلل النصفي، والشلل الرباعي) في مدينة الرياض.

المنهجية: دراسة مقطعية شملت 231 طفلاً يعانون من أنواع فرعية مختلفة من الشلل الدماغي التشنجي تتراوح أعمارهم بين 4 إلى 15 سنة مسجلين في مؤسستين لإعادة التأهيل في مدينة الرياض. تم جمع البيانات باستخدام الفحص السريري والاستبيان. قام الاستبيان بتقييم التركيبة الاجتماعية والتاريخ الطبي والعادات الفموية السيئة. الفحص السريري بتقييم إطباق الأسنان في جميع مراحل التسنين، والعضة المتراكبة، والعضة المعكوسة.

النتائج: من بين جميع الأنواع الفرعية للشلل الدماغي كانت العضة المتقدمة هي العلاقة الأكثر في الأسنان الأولية والمختلطة. يُظهر الشلل المزدوج والشلل النصفي علاقة الناب من الدرجة الأولى بينما يُظهر الشلل الرباعي علاقة الناب من الدرجة الثالثة في الأسنان اللبنية.. أظهرت جميع عينات الشلل النصفي ذات الأسنان الدائمة علاقة من الدرجة الأولى بين الأنياب، وعلاقة الأضراس من الدرجة الثانية، وعلاقة القواطع من التصنيف الثاني الدرجة الأولى. وكانت زيادة القطع الزائد أعلى عند الأطفال المصابين بالشلل النصفي مع وجود فروق ذات دلالة إحصائية (**P = 0.001**) بين الأنواع الأخرى. فيما يتعلق بفئات تراكب العضة، كانت العضة العميقة هي الأكثر ملاحظة دون وجود فروق ذات دلالة إحصائية بين الأنواع الأخرى (**P = 0.143**). كان الأطفال المصابون بالشلل الرباعي أكثر عرضة للإصابة بالعضة المعكوسة الأمامية والخلفية مع وجود اختلافات كبيرة بين الدرجات الأخرى (**P = 0.026** و**P = 0.001** على التوالي). وكان التنفس عن طريق الفم هو العادة الأكثر شيوعا بين جميع الأنواع مع عدم وجود اختلافات كبيرة. كانت عادة مص الإبهام ودفع اللسان أكثر انتشارًا بشكل ملحوظ في حالات الشلل الرباعي من الأنواع الأخرى.

الاستنتاج: الأنواع المختلفة من الشلل الدماغي لها علاقات مختلفة تعتمد على نوع مرحلة التسنين، وكانت عادة التنفس عن طريق الفم هي العادة الأكثر ملاحظة مع عدم وجود علامة إحصائية بين جميع الأنواع الفرعية.