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The Impact of Precocious Puberty on Oral Health and Craniofacial Development in Children: A Scoping Review

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ABSTRACT

Precocious puberty is defined as the appearance of developmental characteristics of secondary puberty before the age of 8 years in girls and before the age of 9 years in boys. Hormonal changes related with this condition can influence oral health and craniofacial growth, not only general physical development. Children experiencing precocious puberty may have advanced dental age, expedited skeletal maturation, malocclusion, temporomandibular disorders (TMD), and alterations in oral microbiota. This study aims to identify the current evidence on the structural and functional impacts of precocious puberty on oral health and craniofacial development in children. This scoping review followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for Scoping Reviews (PRISMA-ScR) guidelines. A systematic literature search was retrieved using PubMed and EBSCOhost, includes publications from 2015 to 2025. The search focused on oral and craniofacial changes in children with precocious puberty, using specific keywords and the Population, Concepts and Context framework. Total of nine studies conducted from 2015 to 2025 on oral and craniofacial characteristics in children with precocious puberty. The studies used various designs, including cross-sectional, case-control, observational, and systematic review. Main topics included dental development, craniofacial growth, TMD, maloclusion, and oral microbiota changes. Most of the research involved children with precocious puberty and performed in several countries, and majority was in South Korea. Children with precocious puberty have substantial anatomical and functional changes in the oral and craniofacial complex. Dental and craniofacial changes occur earlier and progress more rapidly, necessitating timely diagnosis and interdisciplinary management. Awareness of these manifestations is essential for pediatric dentists, orthodontists, and endocrinologists to ensure optimal treatment planning during the critical growth period.

Keyword: Precocious puberty; dental maturity; skeletal maturation; malocclusion; craniofacial development; oral health

INTRODUCTION

Puberty is defined when a child develops secondary sexual characteristics and reproductive function. Puberty generated from a complex sequence of biological events mediated by genetic, hormonal and environmental factors characterized by maturation of gametogenesis and secretion of gonadal hormones (A.Sperling et al., 2020; Kiess et al., 2016; Kliegman RM & Geme JW, Schor NF, 2023). A children begins to develop secondary sexual traits and reproductive function throughout puberty. Adolescence is a time of cognitive, psychological, and social changes, and it includes puberty, which is the outcome of a complicated chain reaction of biological events influenced by hormonal, environmental, and

hereditary variables (Wolf, R. M., & Long, 2016). Puberty begins earlier than chronological age in some children, which is defined as precocious puberty if it happens before the age of 8 years in girls and 9 years in boys. Precocious puberty may be idiopathic or influenced by central nervous system abnormalities, endocrinopathies, or genetic syndromes (Atta et al., 2015; Kiess et al., 2016; Sun et al., 2024). Early activation of HPG axis leads to accelarated somatic growth, bone maturation, and psychosocial changes that may impact child development, including oral and craniofacial (Angelova, 2022; Boyapati et al., 2021).

Puberty indicates the beginning of the development of secondary sexual characteristics and reproductive function of the child. Adolescence is a period of cognitive, psychological, and social transformation, which includes puberty as a major milestone. Puberty is the outcome of a complex series of biological events influenced by hormonal, environmental, and genetic factors (Wolf, R. M., & Long, 2016). During this stage, which typically occurs in females between the ages of 10 and 11 years, the hypothalamic-pituitary-gonadal (HPG) axis is activated, leading to the pulsatile secretion of gonadotropin-releasing hormone (GnRH) and the subsequent development of secondary sexual characteristics (Kendirci et al., 2015).

There has been limited research on precocious puberty that examines its incidence and prevalence. An epidemiologic study based in Denmark, estimated that about 0.2% of girls experience some form of precocious puberty, including central precocious puberty (CPP), peripheral precocious puberty (PPP), or benign variants while the prevalence in boys is less than 0.05%. The condition shows a marked female predominance, with an incidence rate of approximately 20–23 per 10,000 girls, compared to fewer than 5 per 10,000 boys (Atta et al., 2015; Sun et al., 2024).

Oral and craniofacial structures also affected by pubertal hormones. Previous studies have shown that early puberty may be associated with accelerated tooth development, early tooth eruption, malocclusion, and advanced bone maturation (Angelova, 2022). These circumstances are very important to note for pediatric dentists and orthodontists, as they may affect the timing of interceptive treatment, selection of orthodontic appliances, and prediction of craniofacial growth potential. Dental age is often estimated using radiographic methods such as the Demirjian Method, and bone age assessed through wrist maturation indicators, these methods are used as the main diagnostic tools to evaluate the biological maturity of children and adolescents (Tabakcilar et al., 2021).

Children with precocious puberty typically exhibit disparity between their chronological age and biological development, which makes diagnosis and management for this children is more difficult. Current literature on the oral and craniofacial impacts of precocious puberty is limited and fragmented. Studies vary widely in methodology, population demographics, and outcome measures, making it difficult to draw definitive conclusions or establish clinical guidelines. There is a need for a comprehensive synthesis of available evidence to better understand the relationship between precocious puberty and oral developmental markers such as dental age, tooth eruption, and skeletal maturation.

This scoping review aims to map the existing literature on the impacts of precocious puberty on oral health and craniofacial development, with particular attention to dental age,

maloclusion, temporomandibular disorder, oral microbiota, and skeletal growth. By identifying patterns, gaps, and future directions in this field, the review seeks to support more informed clinical decision-making and encourage interdisciplinary collaboration between pediatric dentistry and pediatric endocrinology.

The novelty of this research lies in several key aspects. First, it focuses on the impact of precocious puberty on dental health and craniofacial development, including dental age, tooth eruption, malocclusion, temporomandibular disorders, oral microbiota, and bone growth. Second, it provides a comprehensive scoping review to synthesize fragmented existing research on this topic, offering clearer insights for clinicians. Third, the study promotes interdisciplinary collaboration between pediatric dentistry and endocrinology, aiming to improve integrated clinical decision-making. Lastly, it fills a gap in the literature by exploring under-researched aspects of the relationship between precocious puberty and oral development markers, such as dental age and skeletal maturation.

METHOD

The type of research carried out was scoping review research using the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) instrument. The search process was carried out between January 2015 and April 2025. The initial step involved the development of a Population–Concept–Context (PCC) framework to guide the identification of relevant studies, which was also used to formulate the inclusion and exclusion criteria (Table 2).

Article searches were conducted using predefined keywords and index (as detailed in Table 1), which were applied in two major databases: PubMed and EBSCOhost. This process resulted total of 46 articles—31 from PubMed and 15 from EBSCOhost. After eliminating 8 duplicate entries, 38 articles remained for the title and abstract screening. 23 articles removed after screening due to irrelevance to the research focus, remaining 15 articles for full-text review. In this phase, 6 articles were removed because lack of specific focus on oral or craniofacial manifestations, or insufficient data on association with precocious puberty. As a result, 9 articles that met all inclusion criteria were included in the final synthesis of this scoping review. This scoping review aims to map the existing evidence regarding impact of precocious puberty on oral health and craniofacial development. Selection and screening process of these articles is illustrated in the PRISMA-ScR diagram (Figure 1).

Table 1. Keywords

Database	Query
PubMed	(("puberty, precocious"[MeSH Terms] OR ("puberty"[All Fields] AND "precocious"[All Fields]) OR "precocious puberty"[All Fields] OR ("precocious"[All Fields] AND "puberty"[All Fields])) AND ("puberty, precocious"[MeSH Terms] OR ("puberty"[All Fields] AND "precocious"[All Fields]) OR "precocious puberty"[All Fields] OR ("early"[All Fields] AND "puberty"[All Fields]) OR "early puberty"[All Fields]) AND ("oral health"[MeSH Terms] OR ("oral"[All Fields] AND "health"[All Fields]) OR "oral health"[All Fields]) AND ("craniofacial"[All Fields] OR "craniofacies"[All Fields]) AND ("develop"[All Fields] OR "develope"[All Fields] OR "developed"[All Fields] OR

Database	Query
	"developer"[All Fields] OR "developer s"[All Fields] OR "developers"[All Fields] OR "developing"[All Fields] OR "developments"[All Fields] OR "develops"[All Fields] OR "growth and development"[MeSH Subheading] OR ("growth"[All Fields] AND "development"[All Fields]) OR "growth and development"[All Fields] OR "development"[All Fields]))
EBSCOhost	(precocious puberty or early puberty) AND oral AND dental

Source : PubMed Database, EBSCOhost Database,

Table 2. Inclusion and Exclusion Criteria

Eligibility Criteria	Inclusion Criteria	Exclusion Criteria
Study Type	Observational studies (cross-sectional, case-control, cohort), retrospective studies, systematic reviews	Case reports, narrative reviews, editorials, letters, expert opinions
Publication Type	Peer-reviewed journal articles	Conference abstracts, unpublished theses, book chapters
Language	English	Non-English publications without translation
Year Range	2015-2025	—
Data Collection	Human-based data (clinical, radiographic, or microbiological analysis)	Animal studies, in vitro studies
Study Population	Children (≤18 years) diagnosed with precocious puberty (CPP or PPP)	Adults; children without diagnosis of precocious puberty
Concept	Studies examining oral, dental, maxillofacial, craniofacial or periodontal manifestations related to precocious puberty	Studies focusing solely on systemic or neurological aspects unrelated to oral findings
Context	Conducted in the context of oral health, including pediatric dentistry, orthodontics, periodontics, or radiology related to the oral and maxillofacial region	Studies conducted in non-clinical settings without relevance to oral health

Source: PRISMA-ScR 2018 Statement: Methodology for Scoping Reviews. PLoS Med 15(11): e1002747. https://doi.org/10.1371/journal.pmed.1002747

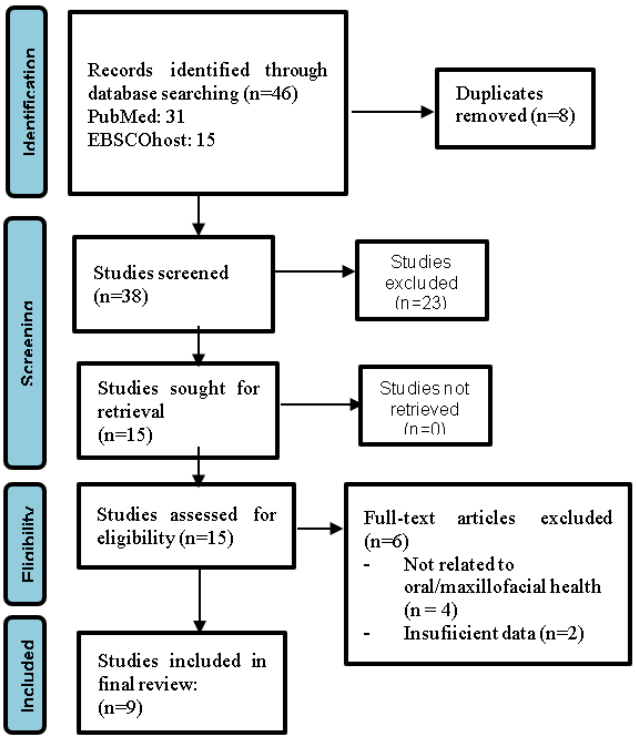

Figure 1. PRISMA-ScR Diagram

RESULT AND DISCUSSION

This scoping review included articles published within the last 10 years, from 2015 to 2025. A total of nine studies were selected based on relevance to the topic of oral and maxillofacial characteristics in children with precocious puberty. The selected studies consist of various research designs, including 3 cross-sectional studies, 2 case-control studies, 2 comparative observational studies, 1 retrospective study, and 1 systematic review. The diversity in study design reflects the exploratory nature of research in the intersection of precocious puberty and oral-maxillofacial development.

Most of the studies was conducted in South Korea, accounting for 4 studies. Other studies were conducted in Iran, Brazil, Turkey, India, and the United States, with 1 study each. Additionally, one study was a multi-national systematic review incorporating research from several countries including Singapore and Switzerland.

In terms of anatomical and clinical focus, four studies evaluated dental development, including dental maturity, calcification stages, and predictive value for pubertal diagnosis using the Demirjian Index. Three studies focused on craniofacial and skeletal growth, analyzing cephalometric characteristics, mandibular development, and skeletal maturation through SMI, CVMI, and hand-wrist radiographs. One study investigated the prevalence and severity of malocclusion and orthodontic treatment needs in girls with central precocious puberty. Another study explored the association between temporomandibular disorders (TMD) and pubertal development, emphasizing the psychosomatic aspects of pubertal transition. Lastly, one study examined shifts in salivary microbiota composition linked to menarche and hormonal changes, suggesting implications for oral health during early puberty.

Most of the studies investigated girls with central precocious puberty (CPP), often

comparing them with age-matched healthy controls. The total number of participants varied between studies, ranging from small case reports with 3 subjects to large-scale studies involving over 400 children.

Discussion

Delays in diagnosis and treatment of precocious puberty can cause development retardation and psychosocial issues, thus it's crucial to distinguish precocious in children as soon as possible. Finding the screening or predicting components of precocious puberty has been the subject of numerous investigations. This scoping review investigated current literature on the oral and craniofacial impact in children with precocious puberty (PP). A total of nine studies were analyzed, covering various domains including dental maturity, dental development abrnomalities, skeletal maturation, cephalometric characteristics, malocclusion, temporomandibular disorder, and oral microbiota. The results of studies demonstrates a coherent pattern, children with PP show accelerated growth development that impacts oral health and craniofacial region.

Orthodontic treatment planning for a growing child with malocclusion is crucial to assess their dental and skeletal development (Chen et al., 2010; Morris & Park, 2012). During orthodontic therapy, the type of malocclusion dictates the use of functional and orthopedic appliances to support normal skeletal growth. To achieve optimal outcomes from orthodontic treatment, it is essential to evaluate and consider the dentofacial growth and development of each child. Chronological age based on birth date indicate significant individual variation and cannot be deemed a reliable indicator of maturity. Therefore, physiologic indicators such as sexual characteristics, skeletal, and dental maturity are utilized to assess patient growth. A common method for measure development in children involves examining the patient's teeth and bones as they mature into adulthood (Chen et al., 2010; Morris & Park, 2012).

Dental development is a dependable indicator of maturation, characterized by a low coefficient of variation and minimal influence from external factors. Among the various methods for assessing dentition development, Demirjian's approach is the most widely recognized; it utilizes panoramic radiography to evaluate the process (Duangto et al., 2016). The maturity score is calculated by count the points assigned to each of the eight developmental phases of the seven permanent teeth located on the left side of the jaw, as outlined in Demirjian's method. This maturity score works to determine a participant's dental age and to monitor their progression in dental maturation. Additionally, standard maturation score data available for specific groups allows for comparisons of dental maturity rates among different participants (Duangto et al., 2016; Tabakcilar et al., 2021).

Tabakcilar et al., (2021) in 2021 showed that children with precocious puberty have a significantly higher dental age compared to their chronological age and skeletal age. This study used the Demirjian Method to assess dental maturation from panoramic radiograph The findings showed in the precocious puberty group, the dental age values were higher than chronologic age values to a statistically significant degree, the difference between dental age and chronological age reached approximately ±1.3 years, a statistically significant result ($p < 0.001$), indicating that dental development in children with precocious puberty progresses more

rapidly than in age-matched peers with normal pubertal development (Tabakcilar et al., 2021).

Baik et al., (2017) explored the relationship between the calcification stages of mandibular posterior teeth (premolars and second molars) and patients' hormonal status. This study found that the degree of tooth calcification in girls with precocious puberty was significantly correlated with levels of LH and IGF-1, two key indicators of pubertal activation. Higher stages of dental maturation (Demirjian stage ≥ E) were associated with positive results on the GnRH stimulation test, with an odds ratio of 8.7. This condition suggests that dental maturation could serve as a biological indicator of puberty and may have potential as a non-invasive predictor of pubertal onset (Baik et al., 2017).

A follow-up study by (Mostafavi et al., 2024) consolidate these findings by demonstrating that stages G and H in the mandibular second molar had high predictive value for the pubertal growth spurt, with an area under the curve (AUC) ranging from 0.84 to 0.92. Tooth in stages G and H by Demirjian Method are important in assessing dental maturation while puberty. Stage G is described by nearly complete root formation. The root walls are parallel, but the apex remains open, with the apical foramen appearing wider than the surrounding periodontal ligament. At this stage, the tooth is in the final phase of development and often coincides with the pubertal growth acceleration phase. Stage H delineate complete dental maturation. The root has reached its full length, and the apical foramen is fully closed, indicating the end of the calcification and tooth formation process. Clinically, teeth at stages G and H, particularly the mandibular premolars and second molars, are considered sensitive biological indicators of hormonal changes during puberty and may be used to predict the peak growth phase in children. Dental maturity is not only associated with the onset of puberty but also with its peak developmental stage, which is crucial for planning orthodontic or facial growth interventions (Mostafavi et al., 2024).

A study by Lee et al., (2018) showed that nearly all mandibular teeth—from incisors to molars—exhibited significantly higher maturation levels in girls with central precocious puberty (CPP) compared to control groups. The correlation between pubertal status and dental maturation ranged from $r = 0.756$ to $r = 0.957$ ($p < 0.001$), indicating a very strong relationship. These findings confirm that the surge in sex hormones associated with CPP biologically stimulates odontogenic tissues, accelerating dentin formation and crown mineralization (Lee et al., 2018).

Dental Developmental Anomalies

Many children with mixed-dentition went to the dentist about the time precocious puberty started to check how their teeth were developing. The purpose of taking radiographs during a dental exam is to see how the permanent teeth are coming in or to find any dental developmental abnormalities (DDAs), such as extra, impacted, or missing teeth. Radiographs provide for the accurate and efficient diagnosis of DDAs based on the irregularity in tooth form or number (Rehan Qamar et al., 2013). During the process of maxillary permanent tooth germ production, the mesiodens, a supernumerary tooth, comes into play. It is normal for the maxillary permanent anterior teeth to erupt between the ages of 6 and 7, with the enamel component of these teeth typically being created between the ages of 3 and 4. Because DDAs can be detected before the beginning of pubertal development symptoms, it could potentially

be used as a predictive factor in the early identification of CPP (Rehan Qamar et al., 2013).

Research conducted by Kim et al., (2020) revealed a significant association between central precocious puberty (CPP) and dental developmental abnormalities in the maxillary region, referred to as maxillary dental developmental abnormalities (DDAs). In this study, children with CPP had a significantly higher prevalence of abnormalities such as mesiodens, impacted teeth, peg-shaped lateral incisors, and congenitally missing teeth, when compared to a group of children with normal puberty. The most dominant finding was mesiodens, which means is supernumerary teeth located in the maxillary central incisor region, found in 42.31% of children with CPP and only 13.33% in the control group. After adjusting for age and gender, mesiodens was significantly associated with CPP, with an odds ratio of 5.52, indicating that children with mesiodens were more than five times as likely to experience precocious puberty (Kim et al., 2020).

The anterior pituitary gland is embryologically responsible for the secretion of LH, FSH and GH hormones derived from oral ectoderm and neural crest tissues, just like the maxillary anterior tooth-forming tissues. This linkage of tissue origin provides a possible biological basis that early activation of the hypothalamic-pituitary-gonadal axis in CPP may affect the development of odontogenic tissues, especially in the maxillary region. Systemic hormonal disorders such as CPP not only affect the reproductive and skeletal systems, but can also trigger anomalies in tooth shape, number and eruption. In this regard, mesiodens may serve as an early clinical indicator of the hormonal imbalance underlying precocious puberty, given that the teeth develop from around 16 weeks gestation (Kim et al., 2020).

Malocclusion, Craniofacial Morphology and Skeletal Maturation

Early onset of epiphyseal ossification and advanced skeletal aging are risk factors for young females with precocious puberty (PP), as they are associated with premature growth spurts. This results in a shorter adult stature, with the severity of the effect being proportional to the intensity of puberty and the timing of its onset (Izquierdo et al., 2012).

Research by Kang et al., (2020) showed the prematurely pubertal hormone in girls with central precocious puberty (CPP) can affect craniofacial growth and accelerate skeletal maturation. the main findings was the high Skeletal Maturity Indicator (SMI) value in the CPP group compared to children of the same age who did not experience early puberty. This suggests that bones in children with CPP undergo compaction and maturation faster, driven by increased sex hormones, especially estrogen. Although the cervical maturation indicator (CVMI) showed no significant difference, the significant SMI value corroborates that hormonal changes in CPP have a systemic impact on skeletal ossification, including on facial and mandibular structures (Kang et al., 2020).

Changes in craniofacial dimensions were also evident in the CPP group. Girls with precocious puberty exhibited a smaller mandibular angle (SN-MP angle) as well as an increase in posterior facial height (S-Go), which illustrates an anterior rotation of the mandible (counterclockwise rotation). This rotation indicates that the mandible is growing faster and more dominantly than the maxilla, which if not compensated for, may lead to skeletal disharmony or a predisposition to Class III skeletal malocclusion. This altered direction of facial

growth can also affect the child's aesthetic balance and stomatognathic function, as well as the child's appearance (Kang et al., 2020).

This relationship between hormonal changes and craniofacial development is important to consider. Estrogen and growth hormone have a role in stimulating bone growth through endochondral ossification, including in the mandibular condyle area which is the major growth center of the mandible. Early activation of the hormonal system in CPP patients triggers faster-than-normal facial bone growth, resulting in a narrower window of orthodontic treatment (Kang et al., 2020).

Research by Lee et al., (2018) also reinforces that girls with precocious puberty experience significant changes in craniofacial growth dimensions and direction. In this study, it was found that children with CPP had significantly greater total mandibular length, as well as longer mandibular ramus growth compared to the control group, in addition to greater posterior facial height, suggesting a predominance of vertical growth in the posterior part of the face. Another feature observed was a decrease in mandibular angles (gonial angle and SN-MP angle), indicating anterior rotation of the mandible and mandibular growth in a horizontal direction. This suggests that hormonal changes in CPP, especially increased estrogen and LH levels, accelerate mandibular and lower facial bone growth, which may affect the patient's occlusion pattern and facial profile (Lee et al., 2018)

De Paula Júnior et al., (2018) specifically investigated the prevalence of malocclusion and orthodontic treatment needs in girls with precocious puberty. The results showed that more than 64% of subjects had severe to very severe malocclusion, and over 80% required moderate to high levels of orthodontic treatment based on the Dental Aesthetic Index (DAI) and the Index of Orthodontic Treatment Need (IOTN). Cephalometric analysis also revealed a tendency toward Class II skeletal malocclusion, associated with maxillary prognathism or mandibular retrognathism. Other notable findings included decreased lower facial height and anterior mandibular rotation, indicating that early puberty can result in an imbalance between upper and lower jaw growth (De Paula Júnior et al., 2018). This study emphasizes that rapid and early hormonal alterations not only accelerate growth but also disrupt the synchronization between jaw and skull base development, leading to jaw disharmony. In this study, malocclusion was not only an occlusal problem but also a manifestation of the systemic imbalance caused by early puberty. children with early puberty not only experience accelerated height and sexual maturity, but also rapid facial growth, thus requiring early evaluation and intervention to prevent long-term complications in occlusion and facial proportions (De Paula Júnior et al., 2018)

Temporomandibular Disorders (TMD)

Puberty is a critical period in adolescent development marked by the activation of the hypothalamic-pituitary-gonadal axis (HPG axis), which causes a surge in sex hormones such as estrogen, progesterone and testosterone (A.Sperling et al., 2020; Kiess et al., 2016; Kliegman RM & Geme JW, Schor NF, 2023). These hormones trigger physical and reproductive changes and have a significant impact on musculoskeletal structures and pain perception, including the stomatognathic system and temporomandibular joint (TMJ). A systematic review by Song, Yap, and Türp. Song et al., (2018) showed that pubertal maturity is a solid factor than chronological

age in explaining the increased incidence of temporomandibular disorders (TMD) in adolescents.Song et al., (2018) The review concluded that TMD symptoms increase during puberty regardless of gender, suggesting a potential link between hormonal maturity and musculoskeletal dysfunction in the orofacial region. Although the review did not isolate children with PP, it suggests a possible area for further exploration in this specific group Song et al., (2018)

Several studies in this review showed a significant increase in the prevalence of TMD symptoms in children who have entered puberty, especially females. Karibe et al., (2015) reported that the prevalence of TMD pain increased from 4% in prepubertal children to 14% in late pubertal children. The estrogen hormone surge typical of female puberty is associated with an increased incidence of TMD. Higher Tanner scores are also associated with increased complaints of masticatory muscle pain and impaired mandibular movement (Karibe et al., 2015).

Estrogen has an significant role in pain and inflammation modulation. It can increase the expression of pain receptors (nociceptors) in TMJ tissues and masticatory muscles, and increase sensitivity to mechanical stimulation. Estrogen also influence cartilage metabolism and remodeling in the TMJ through its effects on chondrocyte cells and estrogen receptors α and β. Changes in estrogen levels during puberty are believed to cause disruption of joint homeostasis and trigger the onset of TMD (Karibe et al., 2015; Song et al., 2018).

Puberty is also characterised by complex psychological and emotional changes (A.Sperling et al., 2020; Kiess et al., 2016; Wolf, R. M., & Long, 2016). The studies in the review found that adolescent girls with TMD also often showed higher levels of somatization, anxiety and depressive symptoms compared to the group without TMD. This supports the hypothesis that hormonal disruption during puberty affects not only musculoskeletal structures, but also central sensitization of pain perception. The manifestation of TMD in adolescents is often multifactorial, encompassing biological, mechanical and psychological aspects (Karibe et al., 2015; Song et al., 2018).

Oral Microbiota

Puberty is associated with increased levels of progesterone and estrogen hormones (A.Sperling et al., 2020; Kiess et al., 2016; Kliegman RM & Geme JW, Schor NF, 2023; Wolf, R. M., & Long, 2016). These hormones act as growth factors for periodontitis-causing bacteria, thus facilitating their growth and colonization in the pubertal age group. Therefore, periodontitis is more common in pubertal individuals compared to children in the pre-pubertal stage. Gingivitis associated with hormonal fluctuations is very sensitive to the presence of hormones, but gingival conditions will generally return to normal by the circumpubertal stage. Most women with healthy gingiva will not experience significant periodontal changes. During puberty, the bacterial population in subgingival pockets increases, and these bacteria can selectively accumulate estradiol and progesterone (Boyapati et al., 2021; Yucel-Lindberg & Båge, 2013).

Increased gingival inflammation and discomfort associated with the menstrual cycle has been reported in adolescents at puberty. The level of gingival inflammation is lower during menstruation compared to ovulation and the premenstrual phase, which is likely due to the

serum hormone estradiol, a natural form of estrogen whose levels peak and fall during ovulation and the premenstrual phase. During the luteal phase of the menstrual cycle, progesterone levels peak, which contributes to an increased inflammatory response in the gingiva and periodontal tissues. These inflammatory conditions are at their peak early in the cycle and will subside over time. This phenomenon is thought to be related to changes in oral bacterial flora (Boyapati et al., 2021; Yucel-Lindberg & Båge, 2013).

In their 2019 study, Mervish et al., (2019) reported that hormonal changes occurring during puberty—particularly around the time of menarche—were linked to shifts in both the composition and diversity of the oral microbiome. The research, which included 25 girls aged 7 to 15 along with their mothers, examined pubertal development, body weight, and gingival health. The findings demonstrated a shift in the oral microbiota after the onset of puberty, marked by a rise in specific bacterial genera such as *Rothia* (from the *Micrococcacea*e family) and members of the *Actinobacteria phylum*, along with a decline in genera including Flavobacteria and those belonging to the *Pseudomonadaceae* family. These changes are associated to endogenous hormonal shifts, particularly estrogen, which is known to modulate the oral environment through influences on saliva, pH, and the mucosal immune system (Mervish et al., 2019).

Microbiologically menarche girls show an increase in aerobic and gram-positive bacteria, such as Actinobacteria, which contribute in carbohydrate metabolism and oral mucosal homeostasis, while a decrease in gram-negative bacteria such as Flavobacteria indicates a potential decrease in bacterial populations normally found in childhood or before puberty. This suggests that puberty induces an ecological shift of the oral microbiota towards a profile resembling that of young adults (Mervish et al., 2019).

Higher levels of bacteria from the genus Scardovia and the order Bifidobacteriales were observed in individuals with gingivitis, both of which are linked to increased risk of dental caries and soft tissue inflammation. The interplay between hormonal fluctuations and gingival inflammation during puberty highlights this developmental stage as a critical window for oral health, in which the microbiota adjusts to new hormonal conditions while potentially increasing susceptibility to periodontal issues. Although the overall microbial diversity, as measured by the Shannon Index, did not differ significantly based on menarche status, notable variations were found at the genus and phylum levels. This suggests that pubertal hormones influence the relative abundance of specific bacterial groups rather than altering the total species count. These results further support the potential use of salivary microbiota profiles as non-invasive biomarkers of pubertal biological changes, with possible applications in the early identification of metabolic or inflammatory disorders (Mervish et al., 2019).

CONCLUSION

Children with precocious puberty show significant changes in the growth and form of the oral and craniofacial systems. The most significant finding is accelerated dental maturation from advanced phases of tooth calcification as compared to chronological and skeletal age. Strong links between these changes and elevated pubertal hormones, particularly LH and IGF-1, indicate that dental development can be a consistent non-invasive biomarker for early pubertal

activation. Apart from dental maturity, craniofacial development patterns are also altered; studies on children with central precocious puberty find early skeletal maturation, mandibular length, and anterior facial height. Over long terms, such acceleration of development may influence facial symmetry and occlusion. Beyond structural changes, hormonal changes linked with puberty can influence oral health problems including temporomandibular disorders (TMD) and salivary microbiota composition, which may indicate psychological and immunological reactions to pubertal transitions. The evidence underlines the need of early and multidisciplinary management in children with precocius puberty given the possibility for altered growth patterns and increased sensitivity to craniofacial and oral health issues.

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