VILNIUS UNIVERSITY
FACULTY OF MEDICINE
INSTITUTE OF DENTISTRY

Malte Yunus Dolff
Dentistry V year, 1 Group

Master´s Thesis

Prevention of Malocclusion

Supervisor: Dr. assist. Vilija Berlin

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Abstract

The misalignment of the upper and lower jaws' teeth, or malocclusion, is a common developmental disorder brought on by genetic, environmental, and functional factors. Malocclusion, if left untreated, can result in dental issues, alterations in the facial structure, and social and emotional problems. Preventive orthodontics can stop the progression of malocclusion and lessen the need for expensive treatment options by educating patients and their parents, keeping track of growth and development, and performing diagnostic procedures. This scientific review emphasizes the prevalence and effects of malocclusion as well as the significance and possibilities of early detection and prevention.

Keywords: Malocclusion, Prevention, Orthodontics, Early intervention, Risk factors, Genetics, Dental Caries, Interceptive Orthodontics, Growth and development

Literature search methodolodgy

A thorough search of the literature was conducted to find relevant studies in PubMed, Web of Science, and Google Scholar between October 1 2016 and March 1, 2023. In order to locate relevant studies, the following search technique was used: "Malocclusion/classification" OR "Malocclusion/epidemiology“ OR "Malocclusion/etiology" OR "Malocclusion/prevention and control"). The included studies' references lists and previously published reviews were searched. The methodology involved the inclusion of studies with broad sample sizes and adequate methodology, such as randomized controlled trials, observational studies, and systematic reviews, to ensure the highest quality of evidence. The time span of the studies included in the review was from April 11, 2013 to March 1, 2023.

Introduction

Malocclusion describes the incorrect relation or the misalignment between teeth of the upper and lower jaw (1). It is rather described as a developmental disturbance than as an actual disease (2). The etiology of this disturbance has genetic, epigenetic environmental and functional components (3). Common genetic explanations for an increase in malocclusion prevalence include an evolutionary reduction in jaw or/and tooth size and inheritance of discordant dental and facial traits. Environmental factors mechanically impact the growth of the jaws and teeth by applying pressures or forces that cause teeth to erupt or shift. The development of the dental arch may be impacted by pressure from the tongue and lip, changes in jaw position brought on by bad oral habits like digit sucking, mouthbreathing or tongue thrusting (4).

It is acknowledged that malocclusion is a complex disorder that can be influenced by a combination of genetic and environmental factors. If untreated malocclusion can lead to abnormal tooth wear, periodontal disease and tooth loss due to higher bacterial infestation. However, not only dental problems can be the consequences; also changes in the facial structure or speaking and chewing difficulties can be observed (5). Similar to caries, also malocclusion can affect patients´ self-esteem and social abilities (6). Therefore, it is extremely important to connect oral health with general health. The „Oral Health Related Quality of Life“, or short OHRQoL, is therefore defined as „a standard of Health of the oral and related tissues which enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment and which contributes to general well-being“(7).

Together with caries and periodontal diseases, malocclusions belong to the most important health problems according to the WHO (8). Due to ethnic and age differences of patients who were considered in studies, assessing the prevalence of malocclusion, the prevalence itself is highly variable (3,8). Between 39% and 93% of children and adults worldwide exhibit malocclusion (8). Germany studies showed that up to 80% of all children are affected (3,9). Another study, which examined the stability of normal occlusion during the transition from primary to permanent dentition, reported that a significant proportion of children developed dental anomalies following the eruption of permanent teeth (10). This study comprised a sample of 350 children who were evaluated at the age of 6 and 12 years old. The findings indicated that 65% of the children developed malocclusion in their permanent dentition, including crowding, overjet, and anterior open bite, despite having normal occlusion in their primary dentition. Especially in early childhood, malocclusion is often associated with unusual suction behavior related to ingestion or lack of space due to early tooth loss in relation to early childhood caries. Prolonged bottle-feeding or thumb sucking are one of the most mentioned causes. However, also disturbances in human development

like cleft lip and palate are listed as common causes (11).

The treatment and prevention of malocclusion is a task for the orthodontic department. Preventive orthodontics deals with patient and parent education, monitoring of growth and development of the dentition and craniofacial structures, diagnostic procedures to predict the occurrence of malocclusions, and the treatment procedures instituted to prevent them (6). Studies have demonstrated that early intervention can prevent the progression of malocclusion and decrease the need for more invasive and costly treatment options in the future (12–15). Especially in the period of mixed dentition preventive orthodontics or interceptive orthodontics are most effective (16). The importance of detecting malocclusion in its early stages and addressing its underlying causes, whether they are genetic or environmental, is highlighted. Additionally, it is crucial to take into account how malocclusion can affect a person's overall health and well-being. This scientific review sheds light on the preventive possibilities of orthodontic treatment in malocclusions. Furthermore, it displays its common causes, frequency and consequences.

Early tooth loss

One of the key contributing factors to malocclusion in the permanent teeth is space loss in the primary dentition (17). The term "premature loss" refers to the loss of a deciduous tooth before the age of typical exfoliation. Tooth decay, trauma, periodontal disease, and early root resorption are the most frequent causes of tooth loss in children (18).

A study conducting 1529 children between the age of 5 and 10 found primary tooth loss in 54.64% of male children and 43.35% of female children (19). The underlying cause of losing posterior teeth prematurely is commonly linked to severe tooth decay, while the loss of anterior teeth at an early age is typically related to dental trauma, tooth decay, extraction of teeth present at birth, and early resorption of tooth roots (20). Children may have a variety of side effects, including dental rotation, dental crowding, craniofacial development abnormalities, formation of hazardous behaviors, especially after an impact, and a shortening of the dental arch (21). Premature tooth loss may cause issues with phonation, changed occlusion, chewing, and facial or dental esthetics (34).

The premature loss of primary anterior teeth can have detrimental effects on the eruption and development of the permanent successor teeth, due to the correlation between the loss of primary anterior teeth and reduction in arch perimeter. This can result in impaction and disturbances in the timing of tooth eruption, such as delays or anticipations (22). The integrity of the deciduous arch is crucial as its compromise can lead to various problems with permanent tooth alignment, such as

reduction of the arch perimeter, extrusion of antagonist teeth, migration and inclination of adjacent teeth, impaction of permanent successor teeth, deviations in eruption and midline, and mismatch between the available space in the dental arch and the space needed for the proper accommodation of successor teeth (18). According to recent studies, the premature loss of upper and/or lower primary incisors may result in loss of anterior space, particularly if it occurs before the eruption of primary canines (23,24). Furthermore, certain other factors may also contribute to space loss, including the presence of non-nutritive habits, deciduous dental arch types, and arch-length discrepancy in the anterior region. These factors may represent potential causes for space loss as adjustments may occur between the teeth after the loss of one of the incisors (23) (18) (25).

The primary first molars are frequently lost due to dental caries or infection, both unilaterally and bilaterally (26). The literature regarding the effects of early loss of primary first molars is controversial. Studies have reported that space loss occurs within the first four to six months after extraction, with migration of the primary canines and permanent incisors towards the edentulous space in both arches (27). Some studies have reported minor mesial movement of maxillary primary second molars as well (24,26,28). Space loss can lead to blocked out permanent canines, which is more common in the maxilla (29). However, other studies have suggested that there is no statistically significant loss in arch width, length, and perimeter following the loss of primary first molars (30) (31). Overall, it seems that patients with full primary dentition and those in the mixed dentition with good intercuspation of permanent molars are less susceptible to space loss. Therefore, some authors question the need for space maintenance following early loss of primary first molars under these circumstances (4,18,23). The literature suggests that there is a high likelihood of space loss when primary second molars are lost, with a greater loss of arch length in the maxilla compared to the mandible (32). The consequences of this loss are more severe when the tooth loss occurs before the eruption of the permanent first molar, as the eruption of this tooth into the oral cavity is guided by the distal surface of the primary second molars.

A study published in 2005 revealed that premature loss of deciduous canines was observed only in cases of class I anteroposterior relationship, while in class II and III occlusal relationships, the premature loss of deciduous teeth was limited to the first and second primary molars, without any loss of primary canines (24). The statement suggests that premature loss of primary canines is not observed in individuals with Class II and III occlusions, but is limited to the first and second primary molars. This may be because the primary canines play a crucial role in guiding the eruption and alignment of the permanent teeth, particularly the lateral incisors and premolars. However loss of primary canines can have significant consequences on the development and function of the dentition. In 2012 (33), a clinical case report highlighted that early loss of primary canines, which can lead to several dental issues, is a common occurrence in individuals with crowded dental

arches. It was observed that the eruption of the lateral incisor is a common factor contributing to this phenomenon. The lateral incisor, as it erupts, exerts pressure on the adjacent primary canine, which can lead to resorption of the mesial portion of the primary canine roots. The resorption of the mesial portion of the roots, weakens the support of the primary canine, leading to its early loss (34). The loss of a primary canine on one side of the dental arch (unilateral) can lead to the migration of adjacent teeth toward the empty space, which can result in malocclusion and misalignment of the teeth (35). The loss of the primary canine can also cause the opposite canine to over-erupt, creating occlusal interference with the opposing teeth (36). The reduced arch length caused by the unilateral loss of a primary canine can affect the positioning of permanent teeth and disrupt proper occlusion. As there is no guidance for the permanent canines to erupt into the proper position, bilateral loss of primary canines can make these problems worse. This may cause the dental arch to collapse, resulting in even more malocclusion and misalignment. A decrease in facial height and a loss of both primary canines on either side of the face may also have aesthetic and functional repercussions (37).

Timely removal of deciduous teeth

In an effort to prevent or minimize the need for orthodontic treatment in the future, clinicians have sought to implement various interceptive treatment approaches that can correct incisor crowding at an early stage. Some of the modalities that have been developed include timely removal of teeth, and orthodontic appliances for space maintenance (38). Unlike early tooth loss, timely removal of deciduous teeth is the practice of extracting primary teeth at the appropriate time during a child's dental development. The timing of deciduous tooth removal is important because it can influence the development and eruption of permanent teeth and impact overall oral health. These extractions are usually performed as an interceptive treatment in order to prevent the development of malocclusion (38). When determining the need for an early removal, it is imperative to consider the individual patient's dental and medical history, along with the clinical judgment of the orthodontist. Early extraction may be indicated for a variety of reasons, including crowding, impaction, ectopic eruption, and abnormal resorption (39–41).

As mentioned prior, primary teeth typically serve as a guide for permanent teeth to emerge in their proper positions, with gradual resorption of the primary teeth roots. However, if root resorption occurs excessively or prematurely, which can be caused by a variety of factors such as trauma, infection, or genetics, it can result in the premature loss or loosening of primary teeth [Fig.1] (42). As a result, the expected sequence of permanent tooth eruption may be disrupted, resulting in

malocclusion (43). This can be seen as permanent teeth erupting in unusual positions or angles, resulting in spacing, crowding, or other types of malocclusion. Extraction of primary teeth with abnormal root resorption can also help prevent further damage to the surrounding teeth and tissues (44). When primary teeth are resorbed excessively or prematurely, the underlying permanent teeth and surrounding bone can be damaged. Early primary tooth extraction can help prevent such damage and promote better oral health outcomes. However if a tooth need to be extracted due abnormal root resorption depends on the extend of root damage (44). Here also a panoramic radiograph can indicate wether a tooth needs to be extracted due to abnormal root resorption beyond repair.

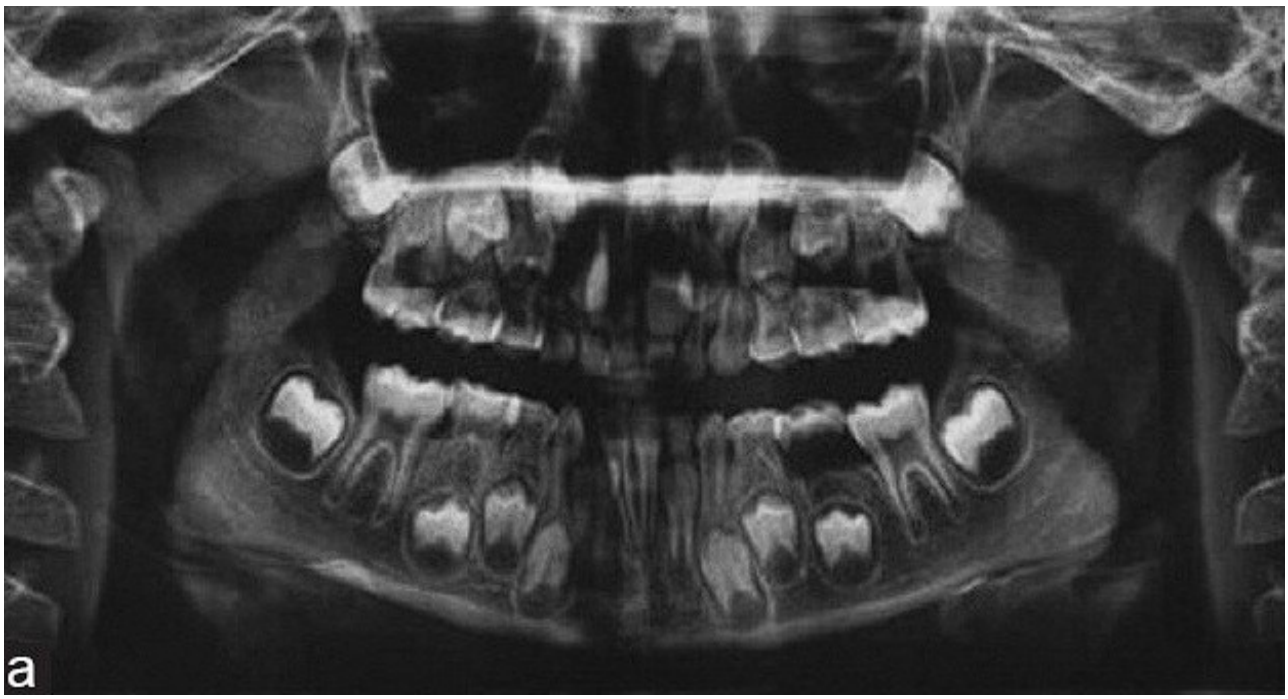
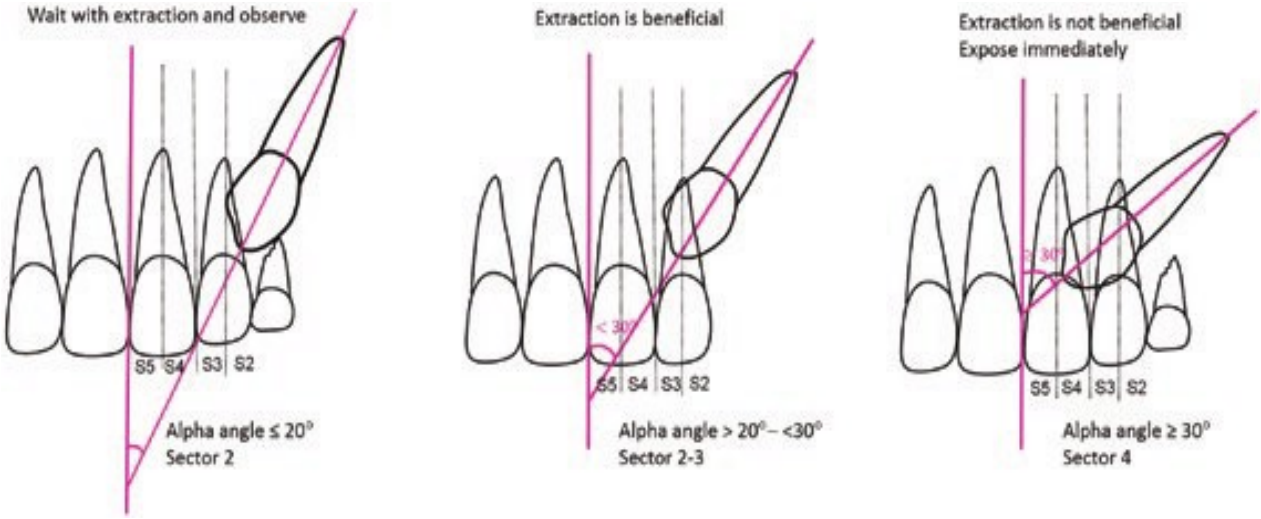


Fig.1 The X-ray revealed severe inflammatory root resorption of the left second mandibular molar and mild root replacement resorption of the right mandibular molar (42) .

A study conducted by C. H. Kau et.al investigated the effectiveness of lower primary canine extractions in relieving crowding of the labial segment (45). The study sample consisted of 83 cases from clinics in Italy, Germany, and Wales, and the groups were followed over a 2-year period. Subjects were randomly allocated to a primary canine non-extraction or extraction group, and dental casts were collected at the start and recall period of the trial. A reduction in lower incisor crowding resulting from lower primary canine extraction was observed, according to the study findings. In both groups, crowding reduced 1.27 mm in the non-extraction group and 6.03 mm in the extraction group, with the difference between the two groups being 4.76 mm ($P<0.05$). Furthermore, the arch

perimeter decreased more in the extraction group by 2.73 mm ($P<0.05$), leaving less space for the eruption of lower secondary canines. As the incisor inclination stayed essentially the same, the loss in arch length was attributed to the molars moving forward. The net gain from extracting deciduous canines was 2.03 mm. Besides the reduction in arch length also incisor retroclination and increased mandibular incisor retrusion have been reported as drawbacks connected with the extraction of deciduous canines (46,47). Another study found that in patients with paletally displaced permanent canines (PDC´s) and present primary canines, extraction of the deciduous canines resulted in more positional changes and faster mean eruption time of the permanent canines (48). Regarding impacted teeth, the prevalence is high in the maxillary permanent canine, which is the second most frequently impacted tooth after the third molar, with an incidence rate of up to 10%. Although the maxillary canine can be impacted in various positions, it is frequently observed to be displaced towards the palate of the dental arch. This impaction is more prevalent in females than males, with a ratio of 2:1. Additionally, the impaction of the maxillary canine can occur either unilaterally or bilaterally and is found in 15-30% of impaction cases (49).

In order to impede any preventable complications in dental development, it is important to examine the toothbuds of canines in children at an early stage. The American Academy of Pediatric Dentistry recommends that children see a dentist for the first time at one year of age, or within six months of the eruption of their first tooth. Children should then go to the dentist every six months for regular check-ups and cleanings (50). In order to determine the necessity of interceptive extractions of deciduous canines, the alpha angle and sector position serve as valuable diagnostic predictors (51,52). The alpha angle is a measurement used in dentistry to determine the position of a canine tooth in relation to neighboring teeth. It is defined as the angle formed by the intersection of two lines: one drawn through the long axis of the canine tooth and another through the long axis of the neighboring incisor tooth. An alpha angle of 10 to 15 degrees is considered normal, while an angle of 20-30 degrees is considered abnormal and may indicate canine malpositioning [Fig.2] (53). The area of the dental arch where the tooth is located is referred to as the sector. Palatally displaced canines are most commonly found in Sector 1, which also contains the central and lateral incisors. They can, however, be found in other areas of the dental arch. Sector 2: between the lateral and central incisor long axes, sector 3: between the lateral incisor and the first premolar long axes and sector 4: between the molars. (51,52). A study on the efficacy of interceptive deciduous canine extraction discovered that when the alpha angle is between 20 and 30 degrees, extraction is most beneficial. Immediate surgical exposure is advised for paletally displaced canines in sector 4 with an alpha angle greater than 30 degrees. Without prior interceptive extraction, canines with an angle less than 20 degrees and located in sector 2 can be observed. It was also discovered that deciduous canine extraction was more beneficial in younger patients with less advanced root development



(54).

Fig.2 Schematic drawing with cut-off points for sector and alpha angle, showing when extraction of the deciduous canine in patients with palatal displaced canine is beneficial (53).

Regarding the outcome of interceptive extractions in palatally displaced canines, a scientific publication by N. Almasoud (55) reviewed 4 clinical studies. In the first study (56) interceptive extraction was found to be associated with a higher rate of successful eruption in cases of palatally displaced canines. PDCs diagnosed radiographically, but not palpable on labial bulge, had a significantly higher eruption rate in the extraction group than in the control group. During the 24-month observation period, 69% of PDCs in the extraction group erupted compared to 39% in the control group. According to the findings of the second study (57), interceptive extraction of nonpalpable PDCs identified using panoramic radiographs may result in a higher eruption rate at extraction sites than at control sites. After an 18-month follow-up period with no dropouts, the study found that 67% of PDCs erupted at extraction sites, while only 42% erupted at control sites. This study also found that the best way to sucessfully manage PDC´s is an early diagnosis between the age of 10 and 11. Using panoramic and periapical radiographs, the third study (58) found PDC´s as a palatally placed permanent canine in the maxilla. The follow-up period was 18 months and PDCs were successfully erupted in 65.2% of cases in the extraction group and 36% of cases in the control group. The use of protective headgear in the extraction group increased the success rate to 87.5%. In the last study reviewed (59), PDCs were diagnosed as intraosseous palatal positioned permanent canines, using panoramic and periapical radiographs, and the patients were followed for a total of 48 months. The study discovered no significant difference in the eruption rate of PDCs between the extraction and control groups, with the extraction group having a rate of 50%. The use of headgear with the extraction group, on the other hand, resulted in an 80% success rate for PDC eruption.

According to these findings, interceptive extraction of primary canines can increase the likelihood of successful PDC eruption. However, more randomized controlled trials are needed to confirm these findings, especially in different population cohorts. Future research must also look into the potential side effects of this intervention, as well as conduct a cost-benefit analysis to determine the feasibility of this approach in clinical practice.

Spacemaintaining

Orthodontic appliances known as space maintainers are custom-fabricated devices that are tailored to the unique oral anatomy of each patient with the aim of retaining the interdental spaces created by missing teeth (60). These devices can be classified into two primary categories: removable and fixed (61). Removable space maintainers, which are commonly fabricated from resin materials, are worn during daytime hours and can be removed for hygiene and alimentary purposes. Removable space maintainers are considered more convenient and less damaging to oral tissues, however, they require high patient compliance and may have a greater risk of breakage or loss. Fixed space maintainers, on the other hand, are affixed to adjacent teeth and remain in situ at all times (62–64). They are usually constructed from materials like metal or ceramic and exhibit greater durability in comparison to removable space maintainers. Fixed space maintainers, which include band and loop [Fig. 3], palatal arch, and lingual arch devices, are known to have high patient compliance but are associated with various disadvantages such as failure of the cement or solder, formation of caries, and long construction time (65). The use of space maintainers as a preventive measure against malocclusion is a widely recognized principle in the orthodontic field. The efficacy of space maintainers in preventing malocclusion can be attributed to several underlying mechanisms.

One of the primary ways in which space maintainers exert their preventive effect on malocclusion is through their ability to inhibit the migration of adjacent teeth into spaces created by missing teeth. This migration of teeth can result in crowding and misalignment, two key indicators of malocclusion. Another mechanism by which space maintainers prevent malocclusion is by preserving the length of the dental arch. The reduction of arch length is a common outcome of tooth loss and can cause crowding, shifting, and misalignment of the remaining teeth if left unaddressed (11,27,31). A study from 2019 (66) dealt with the question whether the premature loss of a deciduous second molar results in a clinically relevant loss of space and arch length reduction. This study aimed to evaluate the effect of premature loss of deciduous second molar on space loss in early permanent dentition stage. The split-mouth evaluation was performed on 32 patients with unilateral loss of deciduous second molar either in the upper or lower arch, while the contralateral

side served as the control. The dental models and radiographs were taken, and the space in the extraction site and control sides were measured and analyzed for space loss and premolar eruption stage. The results showed that the mean combined space before extraction was 25.04mm (±4.25) while the average space post-extraction was 24.61 (±4.27), with a statistically significant difference ($P < 0.01$). Neither the subject's age nor the successor premolar eruption stage were found to be significantly correlated with the amount of space loss (P-values 0.989 and 0.811, respectively). The study concluded that the space loss after premature extraction of the second primary molar was statistically significant, highlighting the importance of using space maintainers at the earliest stage (66).

While the use of space maintainers is widely accepted as a means of preserving proper tooth spacing, there is ongoing controversy regarding their effectiveness in preventing malocclusion and the potential for harm they may cause (64) (67). Space maintainers may interfere with the normal eruption patterns of the permanent teeth, leading to bite problems and malocclusion . Prolonged use of space maintainers may also result in misaligned bite and tooth arrangement, making orthodontic treatment more difficult in the future (68). In addition to these concerns, there is also the potential for decay and infection due to improper cleaning of space maintainers. These devices are made from metal or plastic materials and, if not properly cleaned, can trap food particles and bacteria, leading to decay or infection (69).

Despite these controversies, space maintainers continue to be widely used by orthodontists for the preservation of proper tooth spacing. However, it is important to consider each individual case before deciding on the use of a space maintainer, taking into account factors such as the potential for harm, the likelihood of success, and the patient's unique needs and circumstances.

Fig.3 Band and Loop appliance, Intraoral photograph after 18 months of idiopathic root resorption diagnosis from Fig.1. There were no abnormal signs or symptoms in the follow-up

visit (42)

Dental trauma

Dental trauma specifically refers to injuries that affect teeth and supporting structures such as the periodontal ligament, alveolar bone, and pulp. Dental trauma can be caused by a direct impact, such as a blow or drop to the mouth, or indirect impact, such as sudden changes in pressure or temperature. The severity of the trauma and the degree of injury determines the type and severity of malocclusion. For example, trauma to the jawbone can lead to jaw misalignment. In addition, trauma-induced temporomandibular joint dysfunction can lead to malocclusion and various symptoms such as pain, clicks and limited jaw movement (70). Dental trauma can also cause teeth to become partially or fully displaced. As a consequence, the teeth are no longer in their proper position and may interfere with the bite, resulting in malocclusion. Additionally, when teeth are fractured, the form and size of the teeth may change, inhibiting proper occlusion. Regarding primary dentition, periapical lesions, tooth resorption, pulp canal obliteration, pulp necrosis, and ankylosis are all consequences of dental trauma (71).

A study conducting 839 (72) children found that the prevalence of dental trauma was 25,6% with boys more affected. The most often found dental trauma was fractures of the enamel with 39,4%. However, according to a recent review (73), avulsion is the most prevalent form of trauma observed in primary dentition, while crown fracture is the most commonly encountered form of injury in permanent dentition. Nevertheless, maxillary central incisors are the teeth that are most commonly affected by dental trauma, likely due to their anatomical location in the oral cavity, which provides less protection compared to other teeth. Dental trauma to the frontal incisors can have a significant effect on an individual's Oral Health-Related Quality of Life (OHRQoL). The front teeth are essential not only for appearance but also for function, such as biting and speaking. Any damage or injury to these teeth can cause pain, discomfort, and trouble performing basic oral functions, resulting in a decrease in OHRQoL. Furthermore, trauma to the front teeth can have social and psychological consequences such as embarrassment, low self-esteem, and lack of confidence in social settings. (74). Dental trauma in children is a common global health issue with a significant prevalence. According to recent studies, the prevalence of dental trauma in children ranges from 9% to 39%, depending on various factors such as age, gender, and socio-economic status [Fig.4] (72). Athletes participating in contact sports are at particularly high risk of dental trauma and should wear appropriate protective equipment to reduce the risk of injury. Accidents such as falls and collisions can also cause oral trauma, leading to malocclusion (75). Dental trauma occurs in 7.6% of cases in water polo, 11.3% in basketball, and 13.6% in handball players (76)

Regarding children Preventive measures help reduce the risk of oral trauma and, consequently, the prevalence of malocclusion secondary to trauma. Appropriate protective equipment such as mouthguards, helmets and face shields should be worn when participating in contact sports to reduce the risk of injury (76,77). Additionally, changes to the environment can be made to reduce the risk of falls and other types of accidents. Improving lighting or installing protective grilles and railings. Early intervention is also essential for dental trauma. Prompt treatment can prevent or minimize the occurrence of malocclusion due to trauma. Patients with oral trauma should seek professional dental care immediately to assess and treat any injuries or injuries (73). Clinical examination includes evaluation of fractures and tooth migration to rule out possible complications such as aspiration and migration to the nose and sinuses. Diagnosis includes assessing the nature of the damage by changing tooth color, testing mobility, and testing pulpal vitality. Radiographic evaluations using various imaging techniques are performed to assess the impact of trauma on teeth, roots, periodontal ligaments, and surrounding bone. The Andreasen classification is commonly used to classify dental trauma. Treatment of these injuries depends on the type of injury and may require endodontic treatment, surgical repositioning of the tooth, or flexible splints for stabilization. Early detection and treatment of these injuries are essential to prevent future complications and preserve the patient's natural dentition and optimal occlusion (78).

Name	Year & Country	Sample	Age	Prevalence (%)
Andreasen & Ravn (14)	1972 Denmark	487	Not indicated; retrospective analysis of clinical records	30
Bijella et al. (15)	1990 Brazil	576	10–72 months	30.2
Forsberg & Tedestam (16)	1990 Sweden	1635	1–6 years	12
Jones et al.(17)	1993 USA	493	3–4 years	23
Jones & Nunn (18)	1993 England	135	3 years	12.6
Kramer et al. (19)	2003 Brazil	1545	0–6 years	35.5
Granville-Garcia et al. (20)	2006 Brazil	2651	1–5 years	36.8
Rodríguez (21)	2007 Brazil	543	2–5 years	34.2
Oliveira et al. (10)	2007 Brazil	892	5–59 months	9.4
Robson et al. (22)	2009 Brazil	419	0–5 years	39.1
Jorge et al. (11)	2009 Brazil	519	1–3 years	41.6
Ferreira et al. (23)	2009 Brazil	3489	0–5 years	14.9
Wendt et al. (24)	2010 Brazil	571	12–7 months	36.6

Fig.4 Prevalence of dental trauma in primary dentition (72)

Bad oral habits

A lot of scientific data deals with the question of to what extent bad oral habits, such as mouth breathing or digit sucking, exhibit a negative effect on the development of a normal occlusion (79,80). A habit is a repetitive action that occurs automatically, without conscious thought. The oral cavity is a central and enduring site for the expression of emotions and serves as a source of comfort in moments of anxiety and stress in both children and adults. As a form of self-soothing, individuals may engage in repetitive actions involving the tongue, finger or nail that can provide a sense of relief (81). However, those actions as well as eating habits, non-nutritive sucking, finger sucking, pacifier sucking and early weaning are considered environmental factors causing malocclusion (82–84).

A study in 2021 found that poor oral habits such as unilateral chewing or mouth breathing can develop malocclusion, especially in adults [Fig.5] (85) Nevertheless, the impact of bad oral habits is determined by the characteristics of the habits, including their type, timing, and duration. If non-nutritive sucking habits persist over time, they can result in chronic issues and disrupt the function of the stomatognathic system. This disruption can lead to an imbalance between the external and internal muscles involved in oral function, which can have lasting consequences for oral health and function (86). In 2014 (87), a Mexican study was conducted to determine the prevalence of oral habits among children. The study revealed that a staggering 96.6% of the children who were examined displayed bad oral habits.

The results of this study have significant implications for oral health, as bad oral habits can lead to various dental and skeletal problems, including malocclusions, open bites, and speech impairments. Early detection and intervention are crucial in preventing the development of such problems.

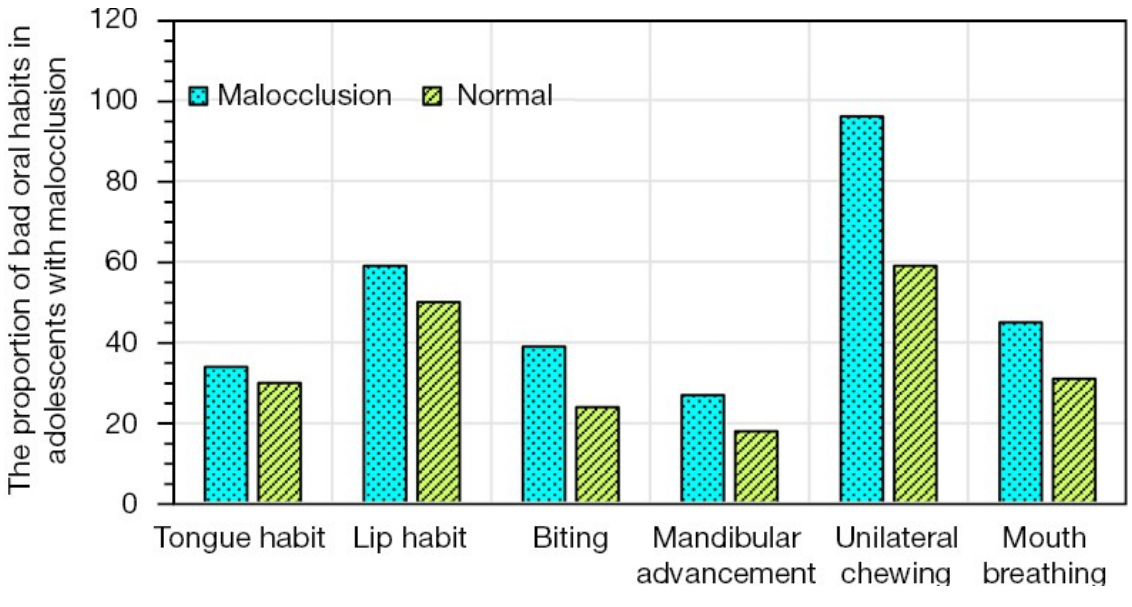


Fig.5 Analysis of the correlation between malocclusion, bad oral habits, in adolescents (85)

Tongue thrusting

Tongue thrusting is a reflexive action where an individual places their tongue between or against their teeth during speaking or swallowing. While it is typically seen in infants, it can persist into adulthood and result in several oral health issues, such as malocclusion (88). The Journal of contemporary clinical dentistry stated that tongue thrusting is prevalent in children between the ages of 4 and 6 years, with reported rates ranging from 40% to 80%. In children between the age of 12 and 15, the prevalence has been reported to range from 3% to 25% (89). Various factors such as an enlarged or small tongue or hyper- or hypotonic tongue muscles can also contribute to tongue thrusting. Tongue thrusting can lead to malocclusion by creating abnormal forces on the teeth, particularly the anterior teeth. When the tongue is pushed forward during swallowing, it can cause the front teeth to shift forward, creating an overbite or open bite (90).

This habit can also lead to the development of a tongue-thrust swallow, which can worsen malocclusion by causing the tongue to push against the teeth during swallowing. Furthermore, during teeth and jaw growth, tongue thrusting can disrupt normal growth and alignment, contributing to malocclusion (91). James Braner and Holt proposed a classification for tongue thrust in 1976 that includes four types (92):

- Type 1 is a non-deforming tongue thrust that does not cause any significant changes to the teeth or oral structures.
- Type 2 is a deforming anterior tongue thrust, which can be further divided into three subgroups: anterior open bite, associated procumbency of anterior teeth, and associated posterior cross bite.
- Type 3 is a deforming lateral tongue thrust, which can also be further subdivided into three subgroups: posterior open bite, posterior cross bite, and deep overbite.
- Type 4 is a deforming anterior and lateral tongue thrust, which can be further divided into three subgroups: anterior and posterior open bite, proclination of anterior teeth, and posterior cross bite.

The relationship between tongue thrusting and malocclusion has been extensively studied in the dental literature. A study conducted in 2014 (89) found that tongue thrusting was significantly associated with the development of open bites in children. In this study, children with a history of

tongue thrusting were more likely to have an anterior open bite, which is characterized by a gap or space between the front teeth when the jaws are closed. Another Study in 2009 confirmed that the prevalence of overjet was significantly increased in tongue thrust individuals (91). In addition to these effects, tongue thrusting can also have significant impacts on speech production. Individuals who frequently thrust their tongue forward during swallowing or speaking may have difficulty articulating certain sounds that require the tongue to be in the correct position. As a result, individuals with speech impediments caused by tongue thrusting may experience social and emotional challenges, such as difficulty communicating with others and feelings of self-consciousness or embarrassment (93).

Besides tongue thrusting the resting position of the tongue is also influential in the development of malocclusion. When the tongue is improperly positioned, it creates an uneven distribution of pressure in the mouth, leading to tooth shifting and eventual malocclusion over time, especially in early childhood while the jaw and face bones are still growing. A study in 2017 found that anterior tongue posture was significantly correlated with mandibular incisor anterior position and mandibular protrusion in class II and class III malocclusion (94). Especially when nasal breathing is impaired mouth breathing is mostly unavoidable. Here the mandible drops and the tongue positions itself low and forward to allow breathing. Logically it is important to emphasize the origin of LTRP (low tongue rest position). The Academy of orofacial myofunctional therapy has stated that both a low resting position of the tongue and the underlying reasons for it can have enduring consequences such as negative impacts on the health and functionality of the temporomandibular joint, stability of the dental occlusion, potential constriction of the maxilla, or chronic maintenance of an open mouth posture (95).

The management of tongue thrusting involves various approaches such as habit-breaking appliances, correction of malocclusion, and myofunctional therapy to correct the tongue's resting position and during swallowing. Habit-breaking appliances such as tongue cribs act as reminders and limit the forward movement of the tongue, while correction of malocclusion is aimed at addressing underlying structural issues. Additionally, myofunctional therapy is an effective approach that aims to retrain the muscles of the mouth and face, including the tongue, to establish proper resting position and swallowing patterns (96).

Myofunctional therapy (MFT) is a treatment concept in orthodontics that aims to optimize the function of the tongue and mouth muscles. The background of this therapy is the observation that a flat tongue position with the tongue lodged between the front teeth is often associated with an open bite, where the front teeth do not come into contact. At the same time, affected children often have habitual mouth breathing and occasionally impaired speech. The fundamental idea of MFT is to improve the tongue position and train the mouth muscles to achieve a relaxed mouth closure

through systematic exercises. It also aims to achieve unobstructed nasal breathing (97). The international journal of orofacial myology published a study providing strong evidence for the positive effects of orofacial myofunctional therapy (OMT) on improving dental occlusion and decreasing dental open bite and overjet. Although the conservative method of measuring may have diluted the results, the study indicates that age is not a factor in predicting the success of therapy, and improvement in open bite and overjet can be achieved without orthodontic intervention (98). As previously noted, the position of the tongue has an association with the respiratory mechanism and the surrounding tongue musculature, which can affect speech and swallowing function. Therefore speech training or speech therapy, which is part of MFT, is a common therapeutic approach in combination with traditional orthodontic therapy to prevent and reverse the negative consequences of tongue thrusting (99).

Regarding the optimal time of MFT, there is no common agreement in the literature. In general, MFT is recommended for Patients above the age of 10 due to the possibility of spontaneous closure of the anterior open bite. For any child undergoing treatment, it is recommended that the program consists of at least 20 sessions, with the initial 10 sessions being devoted to teaching the proper tongue posture. Subsequently, additional sessions will focus on monitoring the progress of the exercises that have been taught. The myotherapy sessions should be ongoing until the exercises become second nature to the child. Each session should be approximately 30 minutes long, with weekly visits initially, followed by biweekly appointments, and ultimately monthly check-ins (96).

Mouth breathing

Mouth breathing is the act of breathing through the mouth rather than the nose, and is a prevalent habit that can result in multiple health problems. The nasal respiratory function plays a critical role in appropriate craniofacial growth and development. Nevertheless, prolonged mouth breathing can induce modifications in craniofacial morphology, such as a constricted palate and a retruded mandible, resulting in malocclusion (86,100).

While bad oral habits are associated with only a few malocclusions, mouth breathing is associated with all of them (101). Besides the manifestation in the craniofacial structures, it is observed that mouth breathers suffer from chronic muscle tension around the oral cavity resulting in a narrower maxillary arch, widening of the cranio-vertebral angle and a posterior position of the mandible (102). Class II malocclusion with protrusion of anterior teeth, crossbite, anterior open bite and primary crowded teeth is considered the most common malocclusions regarding mouth breathing

(103) Studies investigating the correlation between malocclusion and mouth breathing suggest that impaired nasal breathing may contribute to the development of certain dental conditions, such as increased facial height, anterior open bite, increased overjet, and narrow palate (101). However, it is important to note that impaired nasal breathing is not the only or even the primary cause of these conditions. Children who engage in mouth breathing often exhibit skeletal discrepancies, including transverse maxillary constriction, increased anterior facial height, and obtuse mandibular-maxillary plane angle (104). Research has indicated that mouth breathing during the critical period of facial development is linked with a mandible rotation in a clockwise direction and an elevation in the height of the lower anterior face (102,104,105). Additionally, mouth breathing not only affects the appearance of the front of the face, but it also alters the shape of the oropharyngeal airway (106). These observations may be attributed to the inferior tongue posture and hypotonia of facial muscles commonly associated with mouth breathing (107,108)

Mouth breathing can be prevented through a mix of behavioral and medical interventions. Oral habit modification treatment, myofunctional therapy, and breathing exercises are examples of behavioral interventions targeted at retraining the breathing pattern (109,110). Medications may be used to treat underlying disorders such as allergies, nasal congestion, and obstructive sleep apnea. In chronic cases, surgical procedures such as adenoidectomy, tonsillectomy, or nasal septal deviation correction may be required (100,111). Mouth breathing prevention demands a comprehensive approach that addresses the underlying causes as well as the accompanying consequences.

Digit/Thumb sucking and pacifier use

Infants are born with a natural sucking reflex which usually evolves into a comforting behavior. Sucking behavior usually evolves out of the natural nutritive suction behavior. Whenever it is mentioned without a nutritive association it is called nonnutritive sucking behavior or short NNSB (15) Epidemiology studies have shown that non-nutritive sucking habits are prevalent among children globally and across all socioeconomic classes. The incidence of thumb sucking can vary depending on geographic location, with studies reporting an incidence rate ranging from 68% to 82% in children between the ages of 2 to 5 years (14). The frequency of this behavior decreases as children grow older, with only 12.1% of children older than 7 years and 1.9% of 12-year-old children continuing to exhibit the habit (112).

NNSB are considered normal in infants and young children. However, prolonged Non-nutritive sucking behaviors are associated with decreased maxillary arch width, overjet, anterior open bite

and posterior crossbite (113). According to a study conducted by Ferrante et al. in Italy, thumb/digit sucking can be initiated to stimulate nasopalatal receptors and achieve a balance of muscle tension in order to release psychological and physical tension. This suggests a close relationship between finger sucking and a child's psycho-emotional maturity. Most children will cease this habit spontaneously by the age of four years when more advanced self-management skills have developed (114). Studies have also shown that digit sucking can lead to malocclusion by altering the growth and development of the jaw and teeth. The pressure and movement caused by the finger or thumb in the mouth can cause the permanent teeth to become misaligned, the upper and lower jaws to grow unevenly, and the roof of the mouth to change shape. These changes can lead to an overbite or an open bite, as well as other problems such as crossbites, protrusion of the upper front teeth and a high palatal vault (15,115,116).

The sort of digit sucking used also influences the development of malocclusion. Passive digit sucking, in which the infant simply holds their finger or thumb in their mouth without sucking, is less likely to result in malocclusion than active digit sucking. Furthermore, compared to kids who do it less frequently or with less force, kids who suck on their fingers or thumbs for extended periods of time or with great intensity are more likely to develop malocclusion. The duration and frequency of digit sucking has a direct relationship with the severity of malocclusion, the longer and more intense the digit sucking, the greater the malocclusion (82). In a scientific review from 2016 (15), it is stated that each sucking behavior can develop specific types of malocclusion. Children who use pacifiers are less likely to develop overjet compared to children with digit-sucking behavior. Still, other studies suggest that digit sucking is more prone to overjet than pacifier use (117–119). Nevertheless, all studies agree upon a longer duration of NNSB increases the risk of malocclusion (15) (120).

An atypical swallowing pattern or tongue thrusting is typically associated with NNSB and considered related to dentoalveolar or skeletal deformations (101). According to a study from 2001 (108), users at 24 and 36 months of age had significantly different dental arch and occlusion characteristics from those who had ceased sucking by 12 months of age. This study that focused on kids between the ages of two and five discovered that pacifier users had significantly higher overjet (more than 4 mm), openbite, and posterior crossbite. The link between openbite and crossbite was stronger the longer the pacifier use was measured in months. Additionally, between the ages of 2 and 5 years, pacifier users showed a significantly higher rate of overjet (>4 mm), open bite, and posterior crossbite (108).

Parents´ education regarding the effects of abnormal oral habits, children's education and motivation to cease the habits, and the elimination of oral habits through habit-breaking equipment are all crucial first steps in the prevention of parafunctional habits (16) A variety of treatment

options have been proposed for addressing thumb/digit-sucking in children (121). These can include counseling for both the child and their parent, the use of various oral appliances, the implementation of behavior modification techniques such as rewards or incentives for breaking the habit, the application of a disagreeable-tasting substance to the child's thumb, myofunctional therapy, or a combination of these approaches. A scientific review from 2015 (121) evaluated the effectiveness of orthodontic appliances (with or without psychological intervention) compared to no treatment for the cessation of digit sucking habit. The orthodontic appliance was found to be more effective than no treatment, both in the short-term and long-term. The combination of orthodontic appliances with psychological intervention was also found to be effective (121).

Two trials (78 participants) evaluating psychological interventions found that they were effective in the short-term and long-term compared to no treatment. Only one trial found a difference in effectiveness between different active interventions, with the palatal crib being more effective than palatal arch (122,123). Especially psychological intervention and habit reversal training have been shown to be effective approaches in stopping thumb or digit-sucking habits. A study conducting 30 thumbsucking children found that during the first week, habit reversal training resulted in a 92% decrease in thumbsucking, which increased to 95% at the fourth month- and 89% at the 20-month follow-up. In contrast, a treatment involving a bitter-tasting substance produced only a 35% decrease (124).

Habit reversal training (HRT) is a type of behavioral therapy used to help individuals exhibiting repetitive behaviors or habits like thumb sucking, nail biting, hair pulling, skin picking, tics, and other body-focused repetitive behaviors. HRT consists of multiple steps, including identifying a target habit or behavior, recognizing the triggers and conditions that contribute to the habit, developing new substitute behaviors, and consistently practicing the new behaviors (124,125). HRT is divided into five phases: awareness training, relaxation training, competitive response training, motivation protocols, and generalization training. Awareness training involves identifying the habit behavior and its triggers. It includes response description, self-observation and diary monitoring, focusing on the sensations preceding the behavior, and acknowledging high-risk situations for the behavior. Relaxation training aims to reduce stress that leads to habit behaviors, while competing response training replaces undesirable behavior with less conspicuous actions. Motivation training enhances the acceptability of HRT to children and their families, and generalization training involves imagining successful control in situations identified during the awareness stage (126).

Breast feeding/ bottle feeding

Even though breast- or bottle feeding is not considered unusual suction behavior or bad oral habits, various scientific studies deal with the question if breastfeeding has a positive effect on developing Malocclusion (127,128). The WHO recommends exclusive feeding of the child through breastfeeding for the first 6 months and for a minimum of 2 years with complementary foods (129). These recommendations are based on studies dealing with the positive development of the cardiovascular system, reduced risk of gastrointestinal infection and fewer risks of growth defects (130). Scientific evidence shows that functional stimuli such as breathing, swallowing, chewing and sucking affect craniofacial growth and development (131,132). Furthermore, studies suggest that breastfeeding for less than 9 months can be considered a risk factor for posterior crossbite and openbite (13),(9). Another study also suggests that breastfeeding for more than 12 months is associated with a lower risk of overjet, posterior crossbite and open bite (134).

Bottle feeding, or providing an infant with formula or other liquids through a bottle, is a common feeding method for infants and young children. While bottle-feeding has its own set of benefits, such as convenience and flexibility for the caregiver, recent studies have also highlighted the potential negative impact of bottle-feeding on oral health, specifically in relation to the development of malocclusion, or improper alignment of the teeth (135,136). While Breastfeeding seems to support the development of normal occlusion, an Indonesian study in 2019 suggests that bottle feeding is a predisposing factor for developing malocclusion. The type, shape and texture of the artificial nipple on the bottle may cause disturbances in the maxillary development. It is also observed that Overjet is the most common malocclusion connected with Bottle- feeding. The growth of the mandible, on the other hand, seemed to be slowed down due to the easier milk intake and the lower muscle effort (136). Additionally a study from 2018 conducting over 5278 5- year old children from 44 different Brazilian Towns found that decreased rates of malocclusion in 5-year-olds were associated with higher breastfeeding rates at the city level between 9 and 12 months of age, independent of sociodemographic factors. These results underscore the importance of promoting breastfeeding in the child's first year of life (127).

Caries control

Caries is one of the most prevalent infectious multifactorial childhood disorders, which interferes with both everyday activities and proper nutrient intake. According to the World Health Organization (WHO), dental caries can be stopped in its early stages, but because most low- and

middle-income nations lack access to adequate oral health services, their incidence is still on the rise globally (137). Early childhood caries (ECC) is defined as one or more decaying, missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger, according to the American Academy of Pediatric Dentistry (AAPD) (138). Although the prevalence of dental caries has decreased among children in western countries, tooth decay in preschool-aged children remains a significant issue in both developed and developing nations. The prevalence of early childhood caries ranges from 1% to 12% in most developed countries, with a reported rate of 70% in less developed countries and among disadvantaged populations in developed countries (139). Children have a high incidence of caries, which is caused by poor food consumption, poor oral hygiene, and the physical features of deciduous teeth. Cavity formation is then triggered by the localized disintegration and destruction of the calcified tissues of the teeth caused by the acid generation by bacterial fermentation of dietary debris (140). Streptococcus mutans and Streptococcus sobrinus are the primary microorganisms linked to early childhood caries. Lactobacilli also contribute to the development of caries lesions and are involved in lesion progression, but not in its initiation (139). Streptococcus mutans can be transmitted from mother to child through vertical transmission, mainly through the transfer of saliva from the mother to the child during the first 12-24 months of life. Poor maternal oral hygiene maintenance, frequent snacking, and sugar exposure increase the chances of transmission of the infection to the child. Horizontal transmission of microbes may also occur between siblings and caregivers. The risk of early colonization of Streptococcus mutans is higher in infants delivered via cesarean section due to the more sterile nature of this delivery method, which creates an atypical microbial environment (141–143). The presence of fermentable carbohydrates in a child's diet is a significant factor in the development of early childhood caries. If the child consumes high levels of such carbohydrates, the risk of dental caries increases. The question of whether Formula- Milk used in Bottlefeeding promotes the development of Caries, which can ultimately lead to Early Tooth loss and malocclusion, is answered by a study from 2021, conducting 166 13 – 18 month-old infants.The prevalence of caries in breastfed and formula-fed infants was 31.8% and 36.0%, respectively, with no statistically significant difference ($p=0.579$) (144)

Large-scale untreated caries and its effects, like tooth discomfort, directly cause mastication to reduce or become asymmetrical, which alters the distribution of functional occlusal contact [Fig.6]. Poor facial growth and development caused by prolonged unilateral mastication might result in malocclusion and dental-facial abnormalities (4). Mesiodistal crown width might shrink as a result of primary canine and molar interproximal decay. The data shows that adjacent teeth have the propensity to move toward the damaged location, which could result in a shorter dental arch. Loss of arch length may result in issues with chewing, occlusal stability, tooth displacement, dental

crowding, and more (145). Nevertheless, in both mixed and permanent dentitions, caries is thought to predispose to occlusal abnormalities.

Malocclusion makes it harder for patients to practice proper oral hygiene, which leads to an increase in plaque buildup on the surfaces of the teeth and makes them more vulnerable to the onset of caries (146). Especially in deciduous teeth, caries is the main cause of malocclusion. Because of the common misconception that caries in primary teeth need no treatment due to their temporary nature, most often malocclusions develop at an early age. Here most scientific data refers to the space maintaining properties of a deciduous tooth which allows the successor to be guided into its correct position preventing malocclusion (147). The scientific data shows that in sites where primary teeth had to be extracted due to caries, malocclusion developed due to the lack of proper space-maintanance (148)

Fig.6 (4) Severe decay of the first and second mandibular primary molars, intraoral arch length decreased

Nutrition

The connection between nutrition and oral health is evident in the scientific literature (149). Malnutrition, characterized by inadequate or excessive nutrient intake, has a strong worldwide prevalence. Currently, approximately 828 million individuals suffer from hunger, and approximately 1 billion people are obese, accounting for approximately 23% of the world's population experiencing malnutrition (150,151). A 2021 cross-sectional study conducting 220

malnourished children found that malnourishment is directly linked to dental crowding. 98 of the 220 children (44.54%) had Angle's Class I malocclusion with crowding, 18 (8.1%) had spacing, 52 (23.63%) had Angle's Class II division 1 malocclusion, 38 (17.27%) had Angle's Class II division 2 malocclusion, and only 14 (6.3%) had Angle's class III malocclusion (152).

One key nutrient that has been identified as a potential contributor to malocclusion is vitamin D. Recent studies have proposed a correlation between vitamin D deficiency and the development of malocclusion. Vitamin D plays a crucial role in the development and maintenance of the skeleton, including teeth, by regulating the expression of genes involved in bone mineralization and remodeling, as well as the differentiation of cells responsible for bone formation and resorption (153). This deficiency has been correlated with various oral health problems, such as dental caries, periodontal disease, and osteoporosis, as well as an increased risk of malocclusion (154). Data from a study conducted in 2021, suggests that Patients with Vitamin D deficiency were at higher risk of developing malocclusion than Patients with sufficient Vitamin D levels (155). The underlying mechanism behind this correlation remains poorly understood, however, it is hypothesized that vitamin D plays a role in the development and maintenance of jaw bones, affecting the alignment of teeth and their roots, and the function of the temporomandibular joint, which can lead to malocclusion (156,157). Additionally, it may also affect the development of the craniofacial skeleton, leading to malocclusion (158).

Another nutrient that has been associated with preventing malocclusion is fluoride (159). Fluoride is a naturally occurring mineral that is commonly found in water, soil, and food. It is well known for its capacity to fortify tooth enamel, by promoting the remineralization of tooth structure and reducing demineralization, which is as mentioned earlier, a key factor for developing malocclusion. It is a substance that is found in many dental products, including toothpaste and mouthwash, and has been used for many years as a public health measure to prevent tooth decay. Fluoride is also known to affect the development and maintenance of the craniofacial skeleton. A number of studies have investigated the relationship between fluoride exposure and the development of malocclusion. One study found that children who had higher levels of fluoride in their drinking water had a lower risk of developing malocclusion (160). On the contrary, one study found that fluoride may exhibit a negative effect on mandibular development. In this study, a disturbance in horizontal bone growth was documented (161). This research was carried out on rats, and each rat was administered a daily dose of 0.25 mg fluoride from the time of their birth. If this dosage is extrapolated to a child with a weight of 4 kg, the required dosage would be 3.7 mg of fluoride per day. It is important to note that the recommended daily fluoride intake for a child is determined by several factors such as age, weight, and individual needs. According to the Pediatrics Child Health Journal a child between 3 months and 6 years of age should receive a daily dosage of 0,25mg of fluoride a day [Fig.7] (162).

It is also important to exercise caution when interpreting the results of animal studies and applying them to human beings, as the mechanisms and effects of fluoride exposure can vary between species. Additionally, the impact of fluoride intake on human health can also be influenced by other factors such as diet, genetics, and environmental exposure (163). Regardless of this Study, it is evident that fluoride exhibits a positive effect on developing a healthy occlusion. Especially when it comes to remineralizing tooth structure to prevent the progression of caries, fluoride has become indispensable.

Proteins also play a crucial role in the development and maintenance of teeth and jaws. Inadequate protein intake has been linked to delayed tooth eruption and reduced jaw growth, both of which can contribute to malocclusion (164). This is particularly relevant for growing children and adolescents, as the majority of jaw growth occurs during this stage of development. Studies have shown that individuals with malocclusion often have a lower protein intake than individuals with proper tooth alignment (149,165).

	Fluoride concentration	
Age of child	**<0.3 ppm**	**>0.3 ppm**
0 to 6 months	None	None
>6 months to 3 years	0.25 mg/day	None
>3 to 6 years	0.5 mg/day	None
>6 years	1.00 mg/day	None

Fig. 7 Recommended supplemental fluoride concentrations for children (162)

Masticatory performance

When discussing nutrition it is also important to consider the masticatory process of chewing food. The act of chewing involves a complicated interplay of muscles and joints responsible for facilitating the grinding of food within the oral cavity. Scientific data proved that habits like unilateral chewing or weakend muscles due to poor masticatory performance promote temporomandibular disorders, which ultimately can lead to malocclusions (166–168). Additionally, the University of Ottawa conducted a literature review on the relationship between food consistency and malocclusion (169) and found that the decrease in tooth wear, resulting from the shift to an

agricultural diet, has contributed to the development of malocclusion. Furthermore it was shown that the decrease in tooth wear resulted from softer diets. An earlier research has also documented that the ingestion of soft contemporary sustenance, particularly processed foods that can be quickly ingested and digested, has led to a reduction in mastication frequency and meal duration (170). Especially in children it is important to monitor dietary intake in order prevent the emergence of poor masticatory performance (171). In childhood and adolescence, masticatory performance shows an increasing trend that reaches its highest level in young adulthood and then stabilizes, eventually declining with aging. Hence, it is crucial to achieve the maximum possible level of masticatory performance during the growth phase to impede any subsequent reduction in masticatory performance (172).Clinical research has shown that there is a correlation between poor masticatory performance and a higher body mass index (BMI) in children aged 3-5. Additionally, inadequate masticatory performance has been found to be linked to a greater frequency of consuming liquid foods daily, particularly in children with a high BMI (173,174).

As previously mentioned, prolonged unilateral chewing can result in an imbalanced pressure distribution across the teeth, leading to gradual dental displacement (79). A study by Yukie Fujita et al. found a correlation between oral habits and temporomandibular joint disorder symptoms in orthodontic patients, with unilateral chewing being the most prevalent habit (80). The research involved 57 female patients with an average age of 23.5 years who had sought treatment for TMD symptoms and occlusion abnormalities. The most common primary symptom was joint sound, while joint sound and pain were the second most common. The study found that 82.8% of patients had significant oral habits, with unilateral chewing being the most prevalent. The research also revealed that patients with unilateral chewing and bruxism tended to have more complex symptoms compared to those without these habits (80). Unilateral chewing can develop due to dental issues like caries, muscular weakness, injuries, neurological disorders but also habitual preferences. In 2012, a study was conducted to investigate the preference of chewing side during the first and subsequent cycles of mastication for both hard and soft food. The study's results indicated that for hard food, 73.68% of the participants displayed a masticatory preference, while for soft food, 57.89% of the participants exhibited a preference [Fig.8] (84).

Regarding the dynamic occlusal parameters in association with the preferred chewing side (PCS), the „Journal of International Medical Research“ states that tooth contact area, initial contact, and the center of force during maximum intercuspation were primarily towards the preferred chewing side (175). Unilateral chewing on the PCS supports accelerated deterioration of dentition, muscles, and temporomandibular joint. Regular dental examination and treatment of the chewing side are imperative to maintain masticatory efficiency and quality of life (84,175). Not only can the chewing process itself be a contributing factor to malocclusion, but the scientific literature also indicates that

the consistency of food plays a significant role in its development as well .

Chewing cycle(s)	Food type	Preferred side			Overall preference
		Right	Left	None	
First	Hard	63.6%	36.3%	-	-
First	Soft	57.9%	42.1%	-	-
All	Hard	47.36%	26.32%	26.32%	73.68%
All	Soft	47.36%	10.53%	42.11%	57.89%

Fig.8 Chewing preference in the four different occurrences, presented as percentages (84)

Body Posture and TMD

Lately, there has been a rise in the number of research studies examining the potential connections between malocclusion and body posture (176). Body posture refers to how an individual positions and holds their body while standing, sitting, or lying down (177). Maintaining poor body posture can have adverse effects on an individual's health and well-being (178). Extended periods of a sedentary lifestyle, such as sitting at a desk, can result in poor postural habits, including rounded shoulders, a slouched position, and forward head posture (179). These postures, when maintained for long periods, can cause muscle imbalances, limited range of motion, and chronic pain in the back, shoulders, and neck.

In a study involving a sample size of 94 children between the ages of 7 and 14, a high prevalence rate of postural disorders (76%) was observed. Analysis of the data revealed a statistically significant correlation between the presence of kyphotic posture and a reduction in the SNB angle resulting in a retruded mandible (176,180). Another study by Sergio Sambataro et al. also revealed correlations between temporomandibular disorders (TMD) and other pathologies such as headaches, cervical spine dysfunction, and Ehlers-Danlos syndrome (181). According to epidemiological research on TMD, approximately 5 to 6% of the global population will experience a painful incident related to TMJ at some stage in their lifetime (182).

The chain theory of body linkage explains how bad posture can lead to temporomandibular disorder [Fig.9], as the interconnected rings of the upper, middle, and lower body segments must work in coordination. Changes in tissue tension-compression, electromyographic activity of muscles, and alterations in the center of gravity can all contribute to bad posture and TMD. High heels can also

contribute to bad posture and TMD by changing the alignment of the hips and spine (183).

The objective of an older study in 1992 was to examine the potential association between occlusal factors, body posture, and temporomandibular disorders (TMD) in a cohort of 40 children with primary dentition and 40 children with mixed dentition (184). The hypothesis of a correlation between TMD and malocclusion, as well as between body posture and TMD in the study population, was tested. The study findings demonstrated a significant association between forward head position and TMD in the mixed dentition group. Additionally, various occlusal factors were found to be closely associated with TMD in the study population. The prevalence of TMD was 2.5% in primary dentition and 90% in mixed dentition (184).The importance of preventing TMD due to bad body posture is shown in a study which analyzed the prevalence of TMD and its association with malocclusion. The study found a significant association between TMD and malocclusions in the sagittal plane, altered bite, and deviation of the inter-incisive line (185).

In order to promote good health and avoid musculoskeletal disorders, it is essential to prevent poor body posture in children. To achieve this, a combination of education, physical activity, and ergonomic interventions can be utilized to encourage good posture habits among children (186,187). To promote good posture in children, educational initiatives targeted at parents, teachers, and children can increase awareness about the significance of maintaining good posture and the potentially detrimental effects of poor posture. Such programs can provide guidance on how to improve posture as well (188). Physical education programs or after-school activities can include exercises that are effective in enhancing posture, including back-strengthening exercises. Properly fitting furniture and computer equipment can be employed as ergonomic interventions to foster good posture (189,190).

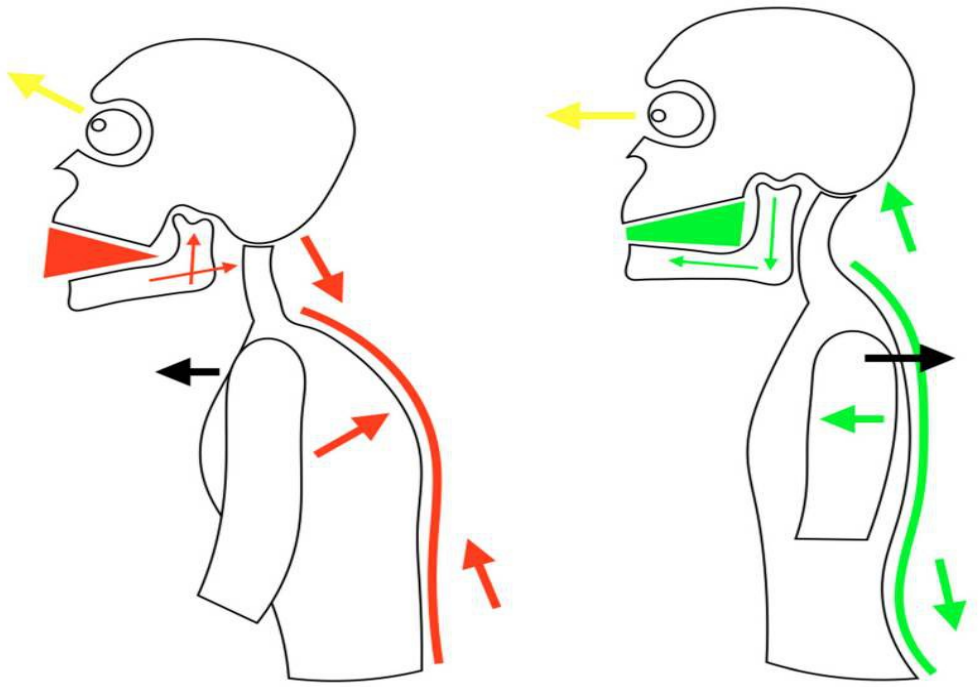


Fig.9 (181) A visual depiction is shown of an asymmetrical posture where the left side is imbalanced and the right side is balanced. It is important to observe that the position of the jaw is closely linked to the posture of the trunk.

Parental Education

The primary influence on children's development of regular oral health behaviors is typically their parents. Parents with greater levels of education tend to have a more beneficial influence on their kids' health behaviors and motivation to preserve good teeth (191). Developing malocclusion out of an oral habit or early childhood caries can mostly be prevented with adequate parental education. A Lithuanian study showed that children with parents who are highly educated are less prone to caries and caries-related disorders than children with low-educated parents. Also, it is shown that families with sufficient income and high education attended more often preventive dental check-ups than families with low income. Especially when it comes to toothbrushing it was shown that children with highly educated parents brush their teeth more frequently than those with low education (191).
On the contrary a study from Turkey in 2020 couldn´t prove that a high level of education of parents directly contributes to positive oral health of their children (192).
However, it is undeniable that proper education on oral hygiene and maintenance as well as teeth in general help parents achieve optimal preventive focus on the development of their children´s teeth and jaws. Oral hygiene, access to dental services, proper care of teeth and gums, use of appropriate cleaning objects, and toothpaste use are all aspects of prevention behavior. These elements related to the specificity of oral care, as well as visits to the dentist, must be carried out on a regular basis from an early age in order to prevent the occurrence of health problems in the body (191,193–195). As mentioned prior poor oral hygiene causes tooth decay, which, if not treated properly, can lead to tooth loss (4,146). Parents, particularly mothers, have a significant impact on children's oral health behavior because they help them develop persistent behavioral routines (196). The participation of parents and other primary caregivers is crucial for caries control, especially for younger children. According to studies, parental education directly affects children's dental health. Dental caries develops as a result of low-education families not paying enough attention to dental care procedures and routine preventive visits to a dentist [Fig.10](191)

Variable	Parental education		P
	High educational level	Low educational level	
Frequency of tooth brushing			
Twice a day	375 (48.5)*	201 (42.4)*	$\chi^2 = 13.456$, $df = 2$, $P < 0.001$
Once a day	350 (45.3)	218 (45.8)	***$P < 0.005$
Several times a week	48 (6.2)**	56 (11.8)**	
Preventive measures			
Applied	224 (33.0)	104 (25.7)	$P = 0.012$
Nonapplied	453 (67.0)	300 (74.3)	

Values are number (percentage).

Fig.10 (191)Frequency of tooth brushing in relation with parental education level

Hyperdontia

Supernumerary teeth, also known as hyperdontia, refer to the presence of extra teeth in the dental arch. These teeth can appear anywhere along the tooth arch and can be functional or non-functional. Supernumerary teeth are uncommon, with a prevalence rate ranging from 0.1% to 3.5% in the general population (197) While these teeth can sometimes be benign and have no negative effects on oral health, they can also cause significant problems, particularly when they are associated with malocclusion [Fig.11](4). The underlying causes of supernumerary teeth remain elusive, however, it is believed that both genetic and environmental factors play a role (198). Some studies have also suggested a genetic component to the development of supernumerary teeth, with some families showing a higher frequency of the condition (12,199). Supernumerary teeth are usually diagnosed through a comprehensive clinical examination and radiographic evaluation. A panoramic radiograph or cone beam computed tomography (CBCT) is required to completely assess the presence, location, and number of supernumerary teeth. It is also critical to correctly determine the type of supernumerary tooth, as various types can have different management options and oral health implications (200).

Supernumerary teeth can play a significant role in the development of malocclusion, particularly when they are located in areas that are critical for proper tooth alignment and occlusion. This is because the presence of extra teeth can cause crowding, shifting, and rotation of other teeth, leading

to a variety of dental and skeletal problems. In some cases, supernumerary teeth can also cause impaction, which is when a tooth is prevented from fully erupting into the dental arch. Impacted teeth can cause several problems, including resorption of adjacent teeth, periodontal disease, and caries. Additionally, impacted supernumerary teeth can also contribute to the development of malocclusion by altering the normal relationship between the upper and lower dental arches. The specific impact of supernumerary teeth on malocclusion will depend on a number of factors, including the location, number, and type of the supernumerary tooth, as well as the stage of tooth development. In some cases, early diagnosis and management of supernumerary teeth may help to prevent or mitigate the development of malocclusion (12,147,200,201).

A scientific review in the „International journal of dentistry“ (202) stated, that the management of supernumerary premolars depends on various factors such as their alignment and impact on occlusion. If the tooth has erupted and does not cause any occlusal problems, it can be left in place. However, if the eruption results in crowding or affects the occlusion, it is advisable to remove the tooth early. In case of unruptured supernumerary premolars, early removal prior to orthodontic treatment is often recommended if diagnosed early. On the other hand, some practitioners recommend delaying the removal until the roots have developed further or the permanent dentition has been established to minimize potential damage to neighboring structures (202).

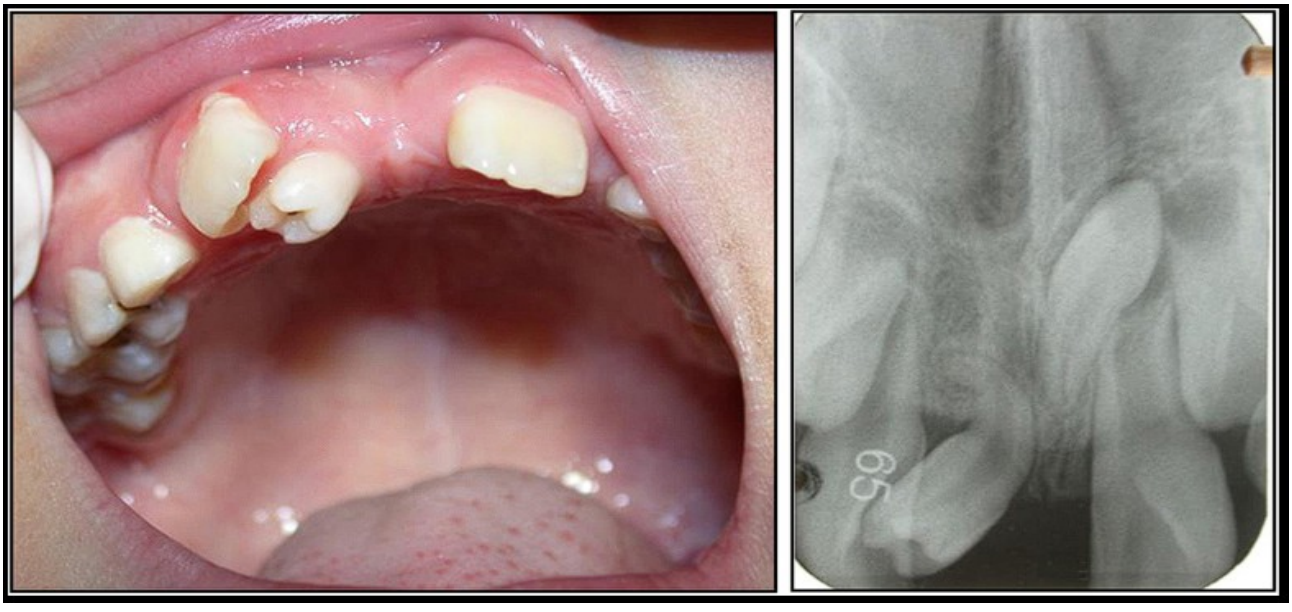


Fig.11 Supernumerary teeth in the area of maxillary anterior teeth resulted in rotation of the right upper incisor and a large Gap; Lef:, intraoral photograph; Right,: Radiographic illustration(4)

Conclusion

In deduction, the prevention of malocclusion is crucial for optimal oral health and quality of life. As mentioned earlier interceptive measures are most effective during the mixed dentition stage, which typically occurs between the ages of 6 and 12 years . This stage allows the orthodontist to identify and treat any developing malocclusion issues, such as crowding, spacing, or an improper bite, before they become more severe and difficult to treat.

During this mixed dentition stage, removing deciduous teeth can prevent crowding and facilitate permanent teeth to emerge. When determining the appropriate timing for tooth extraction, it is crucial to consider factors such as age, dental development, and the individual needs of each patient. Malocclusion due to early tooth loss can be avoided by replacing missing teeth on time, maintaining space, and practicing good oral hygiene. When space is lost due to early primary tooth loss, the amount of space available for permanent teeth to emerge properly is reduced, resulting in crowding, rotations, and other alignment issues. By holding open the space created by the early loss of primary teeth, space maintainers can help prevent space loss and maintain proper tooth alignment.

To reduce the risk of dental trauma and subsequent malocclusion, preventive measures can be taken. Wearing protective gear during contact sports, avoiding risky behaviors such as biting hard objects, and practicing good oral hygiene are all examples of preventative measures. Individuals, particularly parents and caregivers, must be educated on the importance of taking preventive measures to reduce the risk of dental trauma and subsequent malocclusion.

Thumbsucking, tongue thrusting, and mouth breathing can all disrupt the normal growth and development of the teeth and jaws, also resulting in alignment - and other orthodontic issues. Identifying and addressing the underlying causes of the habit, such as anxiety or stress, as well as implementing behavioral interventions to encourage the individual to stop the habit, are examples of these measures.

Myofunctional therapy is a type of treatment that focuses on promoting proper oral muscle function and correcting bad oral habits. Exercises and techniques are used in this therapy to strengthen the muscles of the mouth, tongue, and throat, as well as to improve breathing and swallowing patterns. To avoid long-term orthodontic problems, it is critical to identify and address these habits as early as possible. Regular dental check-ups, good oral hygiene practices, and a healthy diet can all help to control the development of caries. Fluoride treatment and sealants can also provide additional caries protection. When caries is discovered, prompt treatment is essential to prevent disease progression and subsequent malocclusion. Preventing caries and malocclusion can also include lifestyle changes such as limiting sugary and acidic foods and beverages.

Overall, a multidisciplinary approach is necessary for the prevention and management of

malocclusion, involving collaboration between dentists, orthodontists, and other healthcare professionals. Further research is needed to better understand the underlying mechanisms of malocclusion and its prevention in different populations and age groups.

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