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Retrospective Analysis of Midline Deviation in a Group of Patients Attending a Private Pediatric Clinic

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ABSTRACT

Aim: The purpose of this study was to evaluate the association between the eruption of first permanent molars and midline deviation, and compare between midline deviation prevalence in the primary dentition stage and in the early mixed dentition stage.

Materials & Methods: A sample of 606 children (ages 3 to 8 years) was included in this study. The sample was taken from Norwood Pediatric Dentistry, Norwood, Massachusetts. The data collected included: age of subject, the presence/absence of midline deviation, the magnitude and side of deviation if present, the presence of a cross bite, and whether the patient had habits affecting dentition such as bruxism, tongue thrusting, mouth breathing, pacifier use, thumb or finger sucking, and nail or lip or cheek biting.

Results: Midline deviation was recorded in 20.8% of the total number of visits, and it was found to be significantly higher in children with mixed dentition (30.7%) than in children with primary dentition (15.4%) ($P < 0.0001$).

In children with first permanent molars erupted, 32.5% of children had midline deviation, which was significantly higher than the group of children who did not have their first permanent molars present (15.5%) ($P < 0.0001$). There was a statistically significant and positive association between age and midline deviation ($P < 0.0001$). At the last visit with primary teeth, 14.3% had midline deviation, compared to 24.5% at the first visit with mixed dentition stage. The difference between the two percentages was not statistically significant ($P = 0.099$). At the last visit with no permanent molars, 13.9% had midline deviation,

compared to 24.4% at the first visit with a permanent molar. The difference between the two percentages was not statistically significant (P = 0.078).

Conclusions: The prevalence of midline deviation in children in the mixed dentition stage is significantly higher than in children in the primary dentition stage. The prevalence was also higher in children with the first permanent molar erupted compared with children without the first permanent molar erupted. However, when following patients throughout transitioning from one developmental stage to another, it was found that there is no significant difference between the percentage of midline deviation at the last visit with primary teeth compared to the percentage of midline deviation at the first visit with mixed dentition stage. Moreover, there is no significant difference between the percentage of midline deviation at the last visit with no permanent molars and the percentage of midline deviation at the first visit with a permanent molar.

DEDICATION:

To my husband, M. for his continuous love and support.

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My deepest gratitude goes to my principal advisor and all committee members for guiding me and making this research possible.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Retrospective Analysis of Midline Deviation in a Group of Patients Attending a Private Pediatric Clinic

One of the most common problems dentists face is the midline deviation.[1] The dental midline is a midsagittal line bisecting the maxillary and mandibular dental arches. Each arch has its own midline, and when the two lines don't coincide, the condition is called a midline deviation. Midline deviation is often seen in patients with malocclusion especially with class II malocclusion.[1] The problem has a persistent nature and is rarely self-correcting.[1]

Midline deviation poses an esthetic problem,[2] but its importance is far beyond esthetics. It is also a sign that indicates that the occlusion is not normal bilaterally.[1] Midline deviation can be caused by a single factor or it can be multifactorial in origin.[1] One cause is a functional posterior cross bite causing a mandibular deviation.[1]

The most common cause of functional posterior cross bite is the discrepancy in size between the maxilla and mandible.[3,4] It was also found that there is a significant association between sucking habits and posterior cross bite.[5] Other habits, such as mouth breathing and snoring, are potentially harmful to the occlusion as well.[5]

Another cause of midline deviation is the presence of dental interferences that can cause the mandible to shift to one side upon closure, typically, to the symptomatic side, and once interferences are eliminated, the mandible will shift back to its normal position with no deviation.[6]

Some authors also found that head posture could alter the mandibular position since it plays a primary role in dictating it's rest position.[7] The head posture itself was found to be dictated by the dominant eye, with dominancy established very early in life.[7]

Occlusion is thought of as a dynamic functional relationship rather than a static condition.[8] It is influenced by all components of the masticatory system and undergoes constant modification throughout life.[8] Pediatric dentists are responsible for closely supervising the details of the developing dentition starting from the patient's first year of life until adulthood is reached.[9] That is why it is important to consider any observation a clinician might have in order to understand dentition. Clinical observations have revealed that midline deviations can occur around the time of eruption of the first permanent molars. However, there are no studies done to address this observation.

Development of the midface region:

Morphogenesis of the face in the embryo occurs between the fourth and tenth weeks intrauterine.[10] It starts at day twenty-two of development[10,11] with the development of five paired protrusions known as pharyngeal arches,[10,11] which give rise to two maxillary prominences and two mandibular prominences.[10,11]A fifth prominence, the frontonasal prominence, forms as well before the end of the fourth week.[10] The five prominences surround the stomodeum, which is initially separated from the gastrointestinal tract by a thin membrane called the buccopharyngeal membrane.[10]

During the fifth week of development, the two maxillary prominences start to grow, and on the frontonasal prominence, two nasal placodes start to form simultaneously.[10] The nasal placodes then invaginate to form the nasal pits.[10,12] The lateral boundaries of the frontonasal mass are formed by the nasal grooves originating from invagination of the two olfactory placodes.[10,12] The nasal placodes then enlarge outwards to form the medial and lateral nasal processes.[10,12] By the end of the seventh week, the medial nasal processes extend inferiorly to form the intermaxillary segment and fuse with the maxillary process to ultimately form a part of the upper lip, philtrum, and primary palate.[10-12]

The mandible is formed by the fusion of the two mandibular processes. The fusion of the facial prominences occurs due to the migration and proliferation of the underlying mesenchyme, and the intervening grooves disappear as a consequence.[10,11]

Development of the oral cavity:

The primary palate starts to form during the sixth week intrauterine as the facial prominences enlarge around the nasal pits[13,14], which deepen simultaneously to form the nasal passages.[10] The medial nasal processes unite before the end of the sixth week[10]. The primary palate forms from the posterior segment of the intermaxillary process, which additionally forms the nasal cavity.[10]

As the frontonasal prominence extends vertically, the midfacial morphology changes extensively.[13] The medial region of the face elongates and narrows as it grows.[13] The brain and the future face become more separated and the brain takes a superior position to the face.[13] At this stage, the size of the maxillary region grows rapidly especially anteriorly.[13] The superior placement of the brain allows the facial prominences to contact each other and aid in a normal growth of the primary palate.[13] The medial nasal region narrows and elongates as the primary palate develops.[13]

The nasal and oral cavities are originally continuous, but they become separated later by the time the palatal shelves form.[10] The palatal shelves form between the seventh and the eighth weeks as extensions from the medial walls of the maxillary prominences.[10] The secondary palate forms by fusion of the palatal shelves with the primary palate and with each other.[10].

Development of connective tissues and bone:

The two types of tissues, skeletal and connective tissues, originate from neural crest or mesoderm or both.[15] The cartilages are the first element to develop among skeletal tissues, and the morphology of craniofacial cartilages is determined by the activity of Homebox genes.[15] Most of the formed cartilages undergo ossification to form bones, with the exception of a portion of the nasal septum.[15] Some chondrocytes in Meckel's cartilage may directly turn into fibroblasts to eventually participate in sphenomandibular ligament formation.[15]

Mechanisms controlling development:

Embryonic development mechanisms depend on the precise interactions between genetic and environmental factors that control mechanisms such as cell proliferation, programmed cell death, and differentiation.[16] Homebox genes and growth factors are important in controlling development.

Homebox Genes:

The Homebox (Hox) genes are highly conserved genes that play a part in regulating embryonic development.[15,17] In humans, they are 39 in number and exist in four clusters on different chromosomes: Cluster A at 7p15, cluster B at 17q21.2, cluster C at 12q13, and cluster D on 2q31.[17] Hox genes encode for Hox proteins, which are expressed prenatally to regulate development of the embryo and continue to be expressed postnatally throughout adulthood.[17]

During craniofacial development, retinoic acid is thought to play a major part in inducing Hox gene expression.[15] Hox-7, Hox-8, and Hox-9 are expressed in neural crest-derived tissues[18] and they influence morphogenesis by providing positional information signals.[18]

Growth Factors:

Growth factors are polypeptides that stimulate cell growth, differentiation, morphogenesis and embryonic and skeletal development.[18] Several types of growth factors are involved in morphogenesis, one of which is fibroblastic growth factor (FGF).

In humans, the FGF family consists of 23 members which function by binding to cell surface receptors.[19] FGFs functions are not limited to embryonic development, but they are also important throughout human life. FGF18 was found to play a major role during embryonic development and morphogenesis of various organs.[19]

In addition to FGFs, transforming growth factors (TGF) have great importance in craniofacial development.[20] Research has found that *TGFß2, Bmp4* genes were expressed during fusion of medial and lateral nasal processes[11,20], while *TGFß-3* had a role in fusion of

Facial Midline:

The right and left sides of the face are highly symmetrical because the two sides develop under the influence and direction of the same genetic information.[21,22] However, perfect facial symmetry is rarely found in organisms, and morphological asymmetries are commonly found among humans.[23] The deviation from perfect symmetry could be due to environmental and genetic stresses coupled with a lower ability of the organism to buffer the stresses.[21,22]

Midline and esthetics:

Studies have shown that humans find symmetrical faces more attractive than asymmetrical faces.[21] A high level of symmetry in faces is also perceived to be indicative of health, although there was no association found between facial asymmetry and actual health.[24]

In dentistry, facial aesthetics is one of the main objectives of dental treatment.[25,26] In order to achieve the best aesthetic results, the maxillary midline must coincide with the facial midline. This ideal position, however, does not always occur naturally. A study by Khan et al. observing midline coincidence with facial midline in a Pakistani population showed that 82.8% of sample subjects had no dental midline deviation while the remaining 17.2% was found to have a deviation of 0.5mm usually towards the left side.[27] However, a study by

Jayalakshmi et al. showed that 80% of the study population had deviation between facial and dental midline between 0 to 1 mm.[2]

Studies, therefore, were dedicated to finding the aesthetically acceptable amount of midline deviation. A study by Zhang et al. was done to evaluate the threshold under which the midline deviation was considered acceptable. Facial images of 6 subjects with variable facial types were used in the study. The images were altered digitally to change the position of the dental midline and were subjected to evaluation. The mean value of the threshold below which the midline deviation was considered acceptable was 2.4mm.[25] Another study was done by Beyer and Lindaur to find the amount of dental midline deviation that is considered acceptable. One hundred twenty individuals were recruited to evaluate images of two subjects. The images used were altered digitally and different amounts of midline deviation were created. It was found that the mean threshold for aesthetically tolerable midline deviation was 2.2 mm with a standard deviation of 1.5mm.[26]

Midline and Function:

In addition to the aesthetic problems, occlusal asymmetry is associated with functional problems such as temporomandibular joint disorder and bruxism.[23]

a) Temporomandibular Joint disorder:

Temporomandibular disorder (TMD) is a collective term used to describe the signs and symptoms involving the muscles of mastication, temporomandibular joint and its related structures.[28-31] TMD is accepted to be multifactorial in origin with occlusion being one of the major etiological factors.[29] The first report of the association between occlusion and TMD was made by an otolaryngology surgeon named Costen in 1934. He observed how changes in occlusion such as loss of vertical dimension caused positional and anatomical changes in the temporomandibular joint, which manifested itself as ear pain. His hypothesis was based on the improvement he observed in some of his patients following occlusion correction to help establish proper articulation of each condyle within its respective fossa.[29]

It has also been observed clinically that TMD symptoms tend to reduce after occlusal adjustments, but on the other hand, experimental occlusal interferences have been associated with short-term TMD symptoms.[32] In addition, patients who have premature occlusal contacts causing mandibular deviation are more prone to develop TMD symptoms.[32] A study by Fu et al. was done on a group of TMD patients assessing the maxillo-mandibular relationship before and after a short-term flat plane bite plate therapy. Out of the 20 subjects recruited for the study, 13 were diagnosed with myofascial pain, the other 7 had disc displacement with reduction, and all the subjects had midline deviation. After the flat plane bite plate therapy was finished, the mandibular midline position drifted back to a balanced position where the labial frena are aligned, the condylar position was altered, and TMJ pain decreased significantly as well. The flat plane bite appliance allowed the mandibular to assume a more balanced position rather than a position influenced by existing dental interferences.[6]

a) Bruxism:

Bruxism is a spasmodic grinding or clenching of teeth. Unlike chewing, it is nonfunctional, involuntary, and might cause occlusal trauma and damage the periodontium and oral mucosa.[33] Bruxism is multifactorial in origin; some of the factors known to be responsible for bruxism are abnormalities in occlusion, mental disorders, and chronic stress.[33] While some authors believe that bruxism is a reaction to occlusal interferences,[34] others are casting doubt on the belief that occlusal factors are associated with bruxism, and theorizing bruxism to be a consequence of sleep disorders and emotional distress.[35]

Factors contributing to midline deviation:

Breast Feeding:

In addition to its benefits for mothers, breastfeeding has countless benefits for children. Children who were breastfed for long periods of time are less prone to infections and obesity and have higher intelligence than their peers.[36] Breastfeeding also protects children against malocclusion. A meta-analysis showed that breastfeeding was associated with a 68% reduction in malocclusion.[36] Moreover, authors have found that prolonged breast feeding prevents the development of dentoalveolar anomalies such as posterior cross bite[37,38] and anterior open bite.[39] It also promotes appropriate vertical and sagittal relationships between the maxilla and mandible.[37-39]

Pacifier use:

While breastfeeding was found to stimulate normal maxillo-mandibular relationships, the use of pacifiers nullified this protective effect against malocclusion.[38] Pacifiers are used to soothe and comfort children, and are reported to decrease the risk of sudden infant death syndrome,[40,41] but their use is still controversial.[40] A study by Nihi et al. was done to assess the damages the pacifiers caused on children from 2 to 5 years old. The researchers found a significant association between malocclusion and pacifier use, especially when used in high frequency and for a long duration. Some of the occlusal changes observed include anterior open bite, posterior cross bite, and increase in overjet.[42]

Pacifier use is also associated with an increase in mandibular inter-canine width and decrease in maxillary inter-canine width.[42,43] There is no evidence that the use of an orthodontic or a physiologically designed pacifier poses less risk compared with a conventional pacifier.[34,40]

Thumb sucking:

Non-nutritive sucking habits are common during the first two years of life.[34,41] They are likely to cause occlusal changes depending on the frequency, duration, and intensity.[41] Non-nutritive sucking habits' prevalence declines as age increases and is likely to end before 5 years of age.[34,41] However, some children continue the habit even beyond their fifth year. The higher prevalence of digit sucking habits could be due to the inability to remove the object (digit) while a pacifier can be taken from a child.[34,41]

Manifestations of thumb-sucking differ from the pacifier-sucking habit: the anterior open bite resulting from pacifier sucking is typically symmetrical, while the thumb-sucking presents as asymmetrical anterior open bite, proclined upper incisors, and retroclined lower incisors.[41]

Mouth Breathing:

Mouth breathing is the habitual respiration through the oral cavity instead of the nose. The air, therefore, enters the lungs directly without it being filtered, moistened or warmed by the nose.[44] Mouth breathers also have lower oxygen concentration in their blood than nasal breathers and can have sleep disorders and sleep apnea.[45]

Not only is nasal breathing important for general health, but it is also necessary for proper development of the craniofacial complex.[46] The air current flowing through the nose stimulates the lateral growth of the maxilla.[46] Therefore, maxillary constriction is commonly seen in mouth breathers; the shape of the maxillary arch is typically described as a v-shaped, narrow arch.[34,46] Some studies found that mouth breathing is associated with high palatal vault,[46] posterior cross bite,[47,48] long lower facial height,[48,49] and incompetent lips.[48]

Mandibular position:

Since the different body systems work as a single structural unit, several studies were designed to find the relationship between head posture and midline deviation. A study by Pradhan et al. was designed to find the association between head posture and eye dominance, and to find if head posture had an effect on mandibular midline shift. Fifty female subjects were recruited for the study with half the number being TMD patients. Several tests were used to determine eye dominance and natural head rotation. It was found that in all subjects, there was an association between eye dominance and direction of head rotation, and in TMD patients, there was a tendency of the mandible to deviate in the contralateral side of head rotation.[7]

Another study by Silvestrini-Biavati et al. was conducted to investigate the relationship between dental malocclusion, body posture, and eye convergence disorders. Six hundred five children were assessed for posture, occlusion and dentition, eye convergence and dominance. The study found that subjects with vertical anomalies of occlusion, deep bite, and open bite, had a significantly higher prevalence of pathologic gait and right eye dominance.[50] This study was based on the hypothesis that a mandibular shift may lead to adaptations in head position,[50] while the study by Pradhan et al. hypothesized the opposite: the head posture affects mandibular position[7], which sheds the light on the importance of viewing the relationship as a possible two-way relationship, or an association rather than a cause and effect. Nonetheless, this field of research is still growing.[51]

Frenal Midline:

Determination of midline is an important step in most dental procedures.[52] There are many methods to find the midline. Therefore, the conformity of several landmarks with the facial midline was investigated by several authors. One study found that the labial frenum exhibited the least distance to the facial midline.[52] However, using other landmarks such as the incisive papilla was acceptable as well.[52] Others have found that the closest to the facial midline was the midline of the oral commissures, followed by dental midline.[53] while others recommended using the philtrum as a landmark. The borders of some of these structures are not distinct, and the location of the midpoint is hard to determine (in the philtrum for example)[54], which makes their use subjective and unreliable.[53]

The frenum attachment is commonly used by prosthodontics as an anatomical landmark.[55] It is a thin fold of mucus membranes enclosing muscle fibers[56] located in the most anterior part of the dental arch.[55] It functions to attach the lips to the alveolar mucosa and periosteum.[56] The use of labial frenum is a reliable method to determine the midline especially when teeth are not available to determine dental midline due to natural exfoliation or extraction.

Aim:

The aim of this study was to evaluate the association between the eruption of first permanent molars and midline deviation. The prevalence of midline deviation was also compared between the primary dentition stage and the early mixed dentition stage.

Hypothesis:

1. The eruption of first permanent molars is associated with a higher prevalence of midline deviation.
2. The prevalence of midline deviation in the primary dentition is less than in mixed dentition.

Significance:

It is important to study any existent malocclusion in young children because early treatment creates optimum conditions for normal growth and function of the craniofacial skeleton and the stomatognathic system.[3]

Materials and Methods:

A sample of 606 dental records (a total of 1324 visits) of children in early mixed dentition (ages 6 to 8 years) and children with primary dentition (ages 3 to 5 years) was included in this study. The sample was taken from Norwood Pediatric Dentistry, a private practice clinic in Norwood, Massachusetts. All the records from April 1, 2012, to November 20, 2015, were screened in order to find the sample required. Children with a history of orthodontic treatment, acute traumatic injury, craniofacial syndromes, neoplasia, or congenitally missing teeth were excluded.

Data were collected from oral examination forms previously filled out by the pediatric dental specialist working in the clinic. The data collected included: age of subject, the presence/absence of midline deviation, the magnitude and side of deviation if present, the presence of a cross bite, and whether the patient had habits affecting dentition such as bruxism, tongue thrusting, mouth breathing, pacifier use, thumb or finger sucking, and nail or lip or cheek biting. The outcomes were the presence or absence of midline deviation, and the presence or absence of midline deviation at least 1mm.

For patients that were seen for multiple visits, and therefore had several forms in their file, information from all forms was entered into the spreadsheet for comparison between different stages of each patient.

Power calculation:

A power calculation was conducted using nQuery Advisor (Version 7.0). The calculation was based on the prevalence of midline deviation reported in Thilander et al.[57], the intracluster correlation reported in Killip et al.[58], and an odds ratio of 2.0. It indicated that the sample size of n=1324 was adequate to obtain a Type I error rate of 5% and a power of 80%.

Method of midline determination:

Prior to the study, the specialist used labial frenum as a reference to determine dental midline. The facial midline was determined by stretching a dental floss from the midpoint of the nose to the midpoint of the chin.

Statistical Analysis:

Descriptive statistics (counts and percentages for categorical variables, means and standard deviations for continuous variables) were calculated. McNemar's test was used to compare paired proportions; generalized estimating equations (GEE) were used to assess other associations. A p-value less than 0.05 was considered statistically significant. IBM SPSS Statistics software version 22 and SAS version 9.4 were used in the analysis.

The prevalence of a midline deviation was calculated in each group of patients (e.g., the primary dentition group and the mixed dentition group) and the magnitude of the difference was found. The data were examined for midline deviation at the last visit with primary teeth, and at the first visit with mixed dentition for the same patient (when available).

Results:

The mean age of the children included in the study was 4.8 with a standard deviation of 1.5. The plurality of the children were 3 years old (24.9%), followed by 4-year-olds (21.7%) (Figure 1).

During the study period, the majority of the patients seen had primary dentition at the time of the visit (65.0%), while the remaining percentage of patients (35.0%) was in the early mixed dentition stage (Table 1). Out of the children in the early mixed dentition stage, 89.0% had at least one permanent first molar erupted (with or without permanent central incisors erupted) while 11.0% had central lower incisors erupted without permanent first molars (Table 2).

Midline deviation:

Midline deviation was recorded in 275 visits (20.8% of the total number of visits), and was not present in 79.2% of the visits (Table 3). Within the group of patients with midline deviation, a deviation greater than or equal to 1mm was observed in 231 patients (84.0%); the remaining 16.0% had a deviation that was less than 1mm (Table 4).

Midline deviation was found in 30.7% of children with mixed dentition, which was significantly higher than midline deviation in children with primary dentition (15.4%) ($P < 0.0001$)(Table 5). Similarly, midline deviation of 1mm or more was significantly higher in children with mixed dentition (25.7%) than in children with primary dentition (13.0%) ($P < 0.0001$)(Table 6).

In children with first permanent molars erupted, 32.5% of children had midline deviation, which was significantly higher than midline deviation in children with no permanent molars erupted (15.5%)($P < 0.0001$) (Table 7). The percentage of midline deviation of 1mm or more in children with the permanent molar erupted (27.2%) was significantly higher than the group of children who did not have their first permanent molars present (13.0%) ($P < 0.0001$) (Table 8).

Midline deviation was around the same percentage from age 3 to 5 years (16.4%, 17.1%, and 16.1% respectively) and increased as age increased starting at age 6 (Figure 2). Similarly, the percentage of children with midline deviation of 1mm or more was almost constant from age 3 to 5 years (13.0%, 14.3%, and 14.6% respectively) and increased steadily starting at age 6. Figure 3 presents the percentage of children with midline deviation of 1mm or more at each age. There was a statistically significant and positive association between age and midline deviation ($P < 0.0001$) and between age and midline deviation of 1mm or more ($P < 0.0001$).

There were two visits with missing data on the side of deviation. Among visits with midline deviation and valid data on the side of deviation, 50.5% of deviations were found on the right side (Table 9).

Cross bite:

Anterior cross bite was seen in 168 visits, which is 12.7% of the total number of visits, and posterior cross bite was seen in 138 visits (10.4% of visits).

Habits:

The prevalence of habits reported by patient's guardian during the 1324 visits is illustrated in Table 10.

At the point of transition from primary dentition to mixed dentition stage:

Only 98 subjects had available data at both primary and mixed dentition stages. It was found that 20 subjects (20.4%) had no midline deviation at the last visit with primary teeth, but had midline deviation at the first visit with mixed dentition. The majority of patients had no midline deviation at both visits (65.3%). (Table 11).

At the last visit with primary teeth, 14 (14.3%) had midline deviation, compared to 24 (24.5%) at the first visit with mixed dentition stage. A two-sided McNemar's test showed that the difference between the two percentages was not statistically significant (P = 0.099).

At the eruption of the first permanent molar:

It was found that 15 subjects (17.4%) had no midline deviation at the last visit with no permanent molars erupted, but had midline deviation at the first visit with first permanent molar erupted. (Table 12). At the last visit with no permanent molars, 12 (14.0%) had midline deviation, compared to 21 (24.4%) at the first visit with a permanent molar. A two-sided McNemar's test showed that the difference between the two percentages was not statistically significant (P = 0.078).

Discussion:

This study was based on a clinical observation that midline deviations may start with the first permanent molar eruption. The goal was to evaluate this observation and to compare the prevalence of midline deviation in primary dentition stage and in early mixed dentition stage.

The sample used in this study consisted of 606 non-orthodontically treated children that are free of any craniofacial anomalies or tumors. The method of oral examination was uniform for all subjects since all patients were examined by one specialist prior to the study. The results showed that midline deviation was seen in 20.8% of the total number of visits, and a midline deviation greater than 1mm was seen in 17.4% of the total number of visits, increasing as age increased. Thilander et al. conducted a study on children from different developmental stages, resulting in similar findings (13.2%).[57] The subjects in their study were screened for a midline deviation of 2 mm or greater, which may have contributed to the small difference in the reported prevalence. On the other hand, Stahl and Grabowski reported a lower prevalence (4.0%).[59]

The results of this study support the hypothesis that the prevalence of midline deviation is significantly higher in children with mixed dentition than in children with primary dentition. The prevalence of midline deviation of 1mm or more found in primary dentition was 13.0%. That is in agreement with what was reported by Moslemi et al. (13.1%)[60], but higher than what was reported by Thilander et al. (6.7%)[57], Alamoudi (10.0%)[61], and Onyeaso and Sote (2.7%).[62] The high frequency of midline deviation of 1mm or more in early mixed dentition

(25.7%) is in disagreement with what Thilander et al. reported (8.8%)[57] and what Johansdottier et al. reported (7.0%).[63]

Eighty-nine per cent of the children in the mixed dentition stage had at least one permanent molar erupted, so it was expected to find that children with first permanent molars erupted had a significantly higher prevalence of midline deviation compared with children who did not have their first permanent molars present.

A high number of subjects had midline deviation at the first mixed dentition visit (20.4%) and did not have a midline deviation at the last visit with primary teeth, and 17.4% had a midline deviation at the first visit with a first permanent molar erupted and did not have a midline deviation at the last visit with no permanent molars. However, the difference found was not statistically significant. The sample may not have been sufficiently large to demonstrate changes when transitioning from one developmental stage to another, which may account for the lack of statistical significance here. Nonetheless, the findings possibly carry a clinical significance.

At this young age, the presence of mandibular asymmetry can hamper normal craniofacial growth. A review by Thilander and Bjerklin showed an association between a unilateral posterior cross bite with mandibular deviation and some TMD symptoms such as clicking, headache, and pain.[64] When left untreated in a clinical trial, the mandibular asymmetry was found to be greater than in treated cases. Therefore, authors have emphasized on the importance of early treatment of such cases.[65] Moreover, midline deviation was found to be an occlusal characteristic of TMD patients.[66]

In the present study, the midline deviation could possibly have occurred because the permanent teeth erupted into a cross bite or created interferences that caused the mandible to drift away from its normal position. The sample shows a higher prevalence of anterior cross bite (12.7% of visits) and posterior cross bite (10.4% of visits) compared to previous literature. Thilander et al. reported anterior cross bite to be 6.8%, and posterior cross bite to be 4.6% in his study on prevalence of malocclusion in children in Clombia,[57] while Stahl and Garbowski reported anterior cross bite to be 4.6%, and posterior cross bite to be 13.6%.[67] The difference observed could possibly be due to a difference between various ethnic groups. The sample in this study included multiple ethnicities.

It is important for dentists to recognize any malocclusion early so they can intervene or refer to a specialist. Unfortunately, many children are not referred at this stage of development.

This study could be repeated on a larger scale on children transitioning from primary dentition to permanent dentition stage in order to further identify the cause of midline deviation. Another recommendation for future research is to observe the occlusal changes that occur upon transitioning from the mixed dentition stage to the permanent dentition stage and find if the existing problems resolves or persists.

Conclusion:

The prevalence of midline deviation in children in the mixed dentition stage is significantly higher than in children in the primary dentition stage. The prevalence was also higher in children with the first permanent molar erupted compared with children without the first permanent molar erupted. However, when following patients throughout transitioning from one developmental stage to another, it was found that there is no significant difference between the percentage of midline deviation at the last visit with primary teeth compared to the percentage of midline deviation at the first visit with mixed dentition stage. Moreover, there is no significant difference between the percentage of midline deviation at the last visit with no permanent molars and the percentage of midline deviation at the first visit with a permanent molar.

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APPENDICES

Appendix A: Tables

Appendix B: Figures

Appendix C: Oral examination from

Appendix A: Tables

Table 1: Percentage of children with primary dentition and children with mixed dentition.

Dentition type	Frequency	Percent
Primary	861	65.0
Mixed	463	35.0
Total	1324	100.0

Table 2: Percentage of children with permanent molars within the mixed dentition stage.

Permanent Molars	Frequency	Percent
Absent	51	11.0
Present	412	89.0
Total	463	100.0

Table 3: Counts and percentages of subjects with midline deviation.

Midline deviation	Frequency	Percent
Absent	1049	79.2
Present	275	20.8
Total of subjects	1324	100.0

Table 4: Counts and percentages of subjects with midline deviation greater than or equal to, or less than, 1mm.

Midline deviation	Frequency	Percent
Greater than or equal to 1mm	231	84.0
Less than 1mm	44	16.0
Total of subjects with midline deviation	275	100.0

Table 5: Midline deviation in the group of children with primary dentition and children with mixed dentition.

Type of Dentition		Midline Deviation		Total
		No	Yes	
Primary	Count	728	133	861
	% Within Primary	84.6%	15.4%	100.0%
Mixed	Count	321	142	463
	% Within Mixed	69.3%	30.7%	100.0%
Total	Count	1049	275	1324
	% Within Total	79.2%	20.8%	100.0%

Table 6: Midline deviation of 1mm or more in the group of children with primary dentition and children with mixed dentition.

Type of Dentition		Midline Deviation ≥ 1mm		Total
		No	Yes	
Primary	Count	749	112	861
	% Within Primary	87.0%	13.0%	100.0%
Mixed	Count	344	119	463
	% Within Mixed	74.3%	25.7%	100.0%
Total	Count	1093	231	1324
	% Within Total	82.6%	17.4%	100.0%

Table 7: Midline deviation in children with and without permanent molars erupted.

First permanent molar		Midline Deviation		Total
		No	Yes	
Absent	Count	771	141	912
	% Within Absent	84.5%	15.5%	100.0%
Present	Count	278	134	412
	% Within Present	67.5%	32.5%	100.0%
Total	Count	1049	275	1324
	% Within Total	79.2%	20.8%	100.0%

Table 8: Midline deviation of 1mm or more in children with and without permanent molars erupted.

First permanent molar		Midline Deviation ≥ 1mm		Total
		No	Yes	
Absent	Count	793	119	912
	% Within Absent	87.0%	13.0%	100.0%
Present	Count	300	112	412
	% Within Present	72.8%	27.2%	100.0%
Total	Count	1093	231	1324
	% Within Total	82.6%	17.4%	100.0%

Table 9: Side of deviation in children with midline deviation.

Side of deviation	Frequency	Percent
Right	138	50.5
Left	135	49.5
Total	273	100.0

Table 10: The prevalence of habits in the study population.

Oral habit	Total	Percent
Bruxism	166	12.5
Tongue thrust	40	3.0
Mouth breathing	30	2.3
Pacifier use	66	5.0
Thumb or finger sucking	90	6.8
Nail, lip, or cheek biting	115	8.7

Table 11: Midline deviation at the last visit with primary dentition and the first visit with mixed dentition.

Visit		First Mixed		Total
		No deviation	Deviation	
Last Primary	No deviation	64	20	84
	Deviation	10	4	14
Total		74	24	98

Table 12: Midline deviation at the last visit with no permanent molar and the first visit with permanent molar.

Visit		First visit with a permanent molar		Total
		No deviation	Deviation	
Last visit with no permanent molar	No deviation	59	15	74
	Deviation	6	6	12
Total		65	21	86

Appendix B: Figures

Figure 1: Distribution of the study subjects by age.

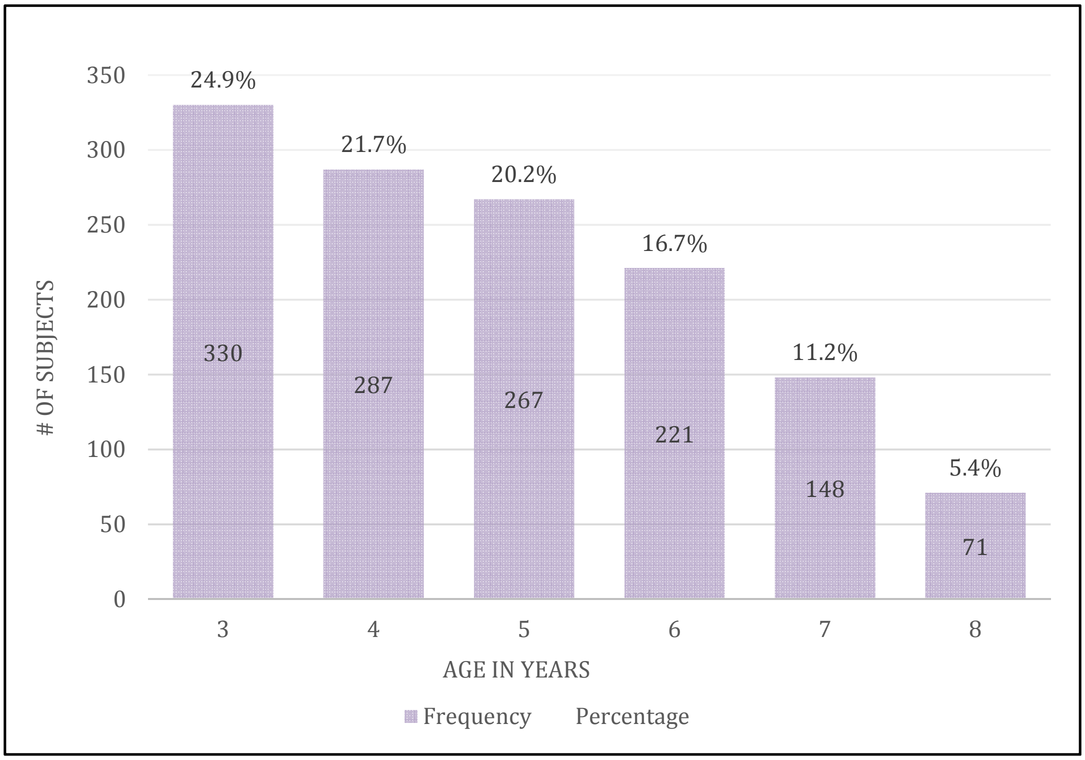


Figure 2: The percentage of midline deviation at each age.

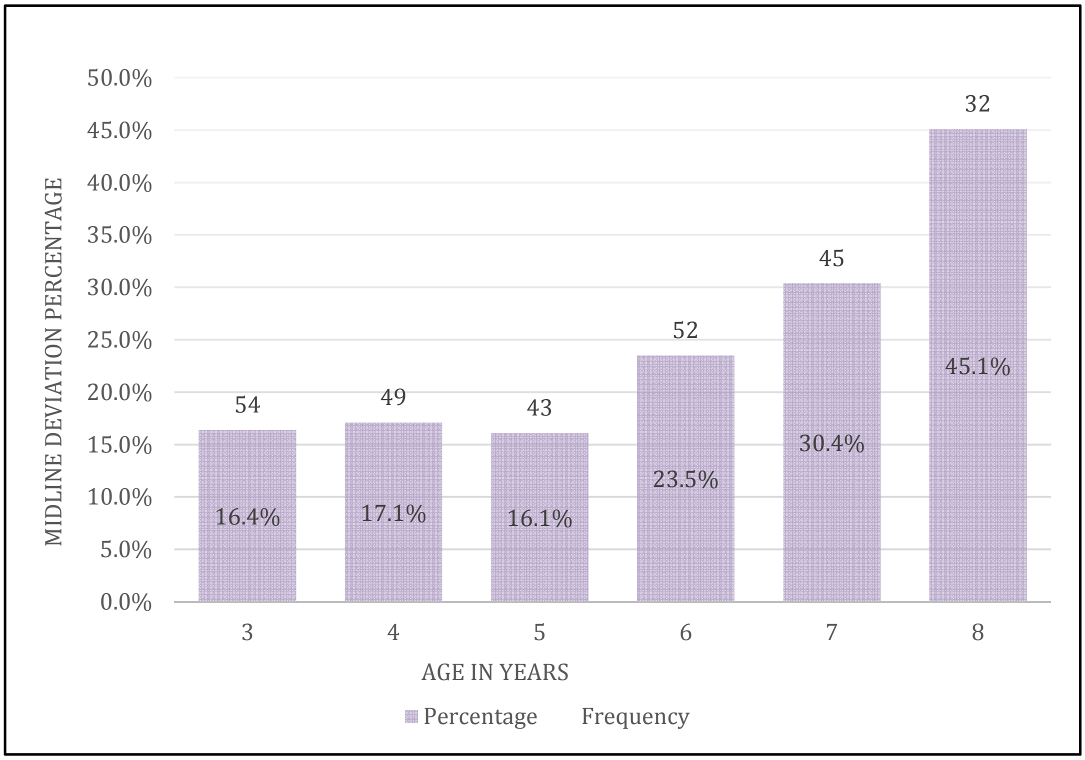
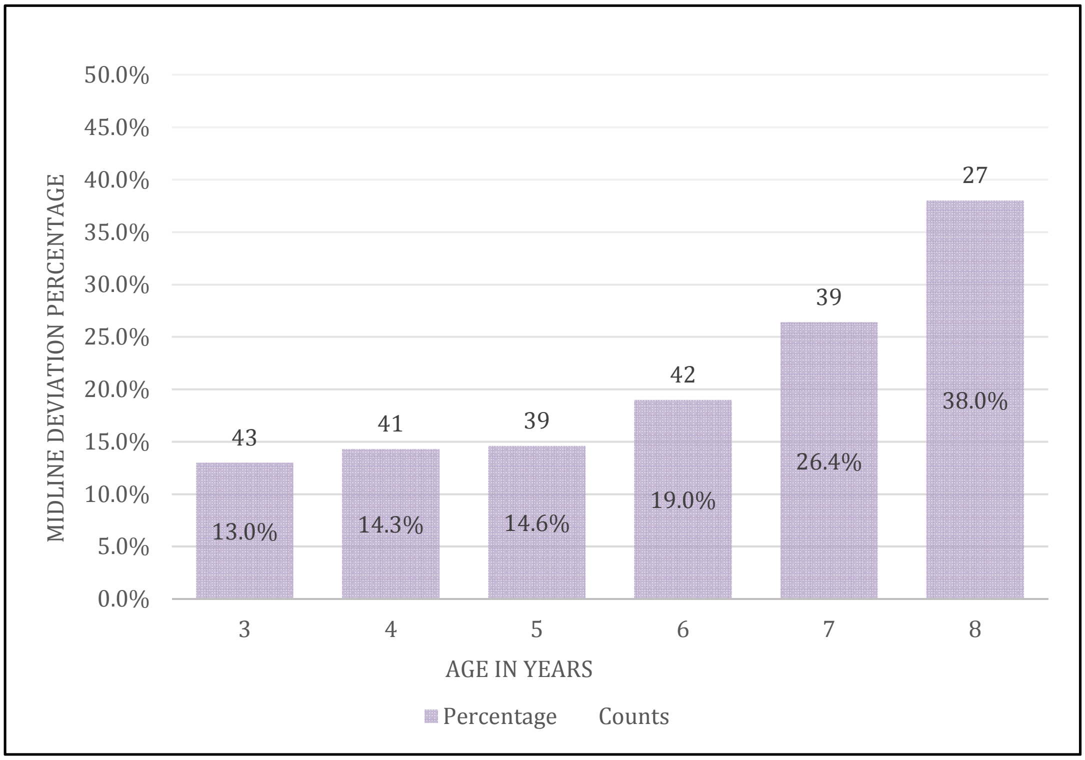
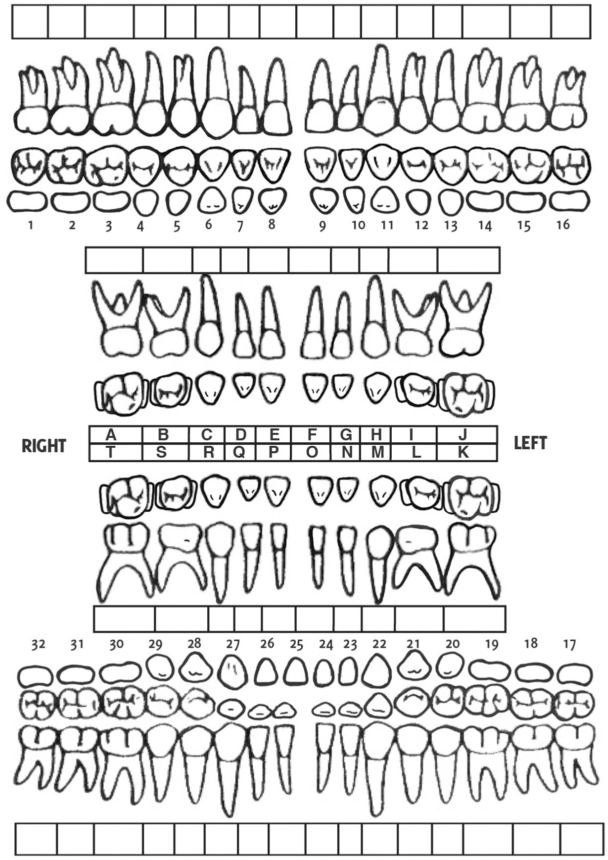


Figure 3: The percentage of midline deviation of 1mm or more at each age.



Appendix C: Oral examination form

INITIAL ORAL EXAM



Name:____
Date:________________________________ Age:________
Chief Complaint:_______________________________________
____
P.D.H.____
____
P.M.H.____
____

Vital Statistics
Height_______________ Weight (Kg=1 lbs /2.2)__________
Blood Pressure________ Heart Rate___________________
Respiratory Rate_______
Behavior:____
Oral Hygiene Index: (Score 0-3)
Labial Max. Right Central Incisor __________
Lingual Mand. Left Central Incisor __________
Buccal Max. Right Molar __________
Buccal Max. Left Molar __________
Lingual Mand. RIght Molar __________
Lingual Mand. Left Molar __________
O.H.I. Total _________ /18=________

Intraoral Exam - Hard Tissues
Missing Teeth____
Mobility____
Periapical Pathology___________________________________
Caries____
Impacted or Unerupted Teeth____________________________
Fractured Teeth______________________________________
Trauma____
Comments: ____

Intraoral Exam - Soft Tissues
Mucosa ________________________________ Floor of Mouth ______________________
Swelling/ Fistula ___________________________ Max Frenum ________________________
Palate ___________________________________ Salivary Glands ______________________
Tongue ___________________________________ Gingiva ____________________________

Extraoral Exam
Facial Symmetry __________________________
Lymph Modes ____________________________
Skin _____________________________________
Lips _____________________________________

Comments: ____

Occlusion Assessment: ____Primary ____Mixed ____Permanent
Facial Profile: ____Concave ____Convex ____Straight Skeletal Classification: _____________________________
Mandibular Plane Angle: ____High ____Average ____Low

Primary Molar Relationship (terminal plane):
Right: ____Mesial ____Straight ____Distal
Left: ____Mesial ____Straight ____Distal

Canine Relationship:
Right: ____Prim. ____Perm. ____Class I ____Class II ____Class III ____End to end
Left: ____Prim. ____Perm ____Class I____Class II ____Class III ____End to end

Permanent Molar Relationship:
Right: ___Class I ___Class II ___Class III ___End to end
Left: ___Class I ___Class II ___Class III ___End to end

Primary Dentition Spacing:
Primate: ___Yes ___No
Incisor: ___Yes ___No

Midline Deviation: ___Yes ___No Describe:____
Over jet:____mm Overbite____ %____mm Open Bite: ____Yes ____No Comments:___________________________
Arch Space Estimation: Maxillary: ____Adequate ____Slightly Deficient ____Deficient
Mandibular: ____Adequate ____Slightly Deficient ____Deficient

Crowding: Maxillary: ____Yes ____No Comments:_______________________________________
Mandibular: ____Yes ____No Comments:_______________________________________
Cross bite: Anterior: ____Yes ____No Comments:_______________________________________
Posterior: ____Yes ____No Comments:_______________________________________
Habits: Bruxing: ____Yes ____No Tongue Thrust ____Yes ____No Mouth Breathing:____Yes ____No Pacifier:____Yes ____No
Thumb/Finger ____Yes ____No Nail,Lip,Cheek Biting: ____Yes ____No Other:_____________________________
Nursing: Breast feeding stopped at _____________ Bottle feeding stopped at ______________