EXPERIMENTAL STUDY

Changes in the mandibular dental arch during the late mixed dentition stage: Experimental study

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Abstract

Objective: To determine the dimensional changes in the mandibular arch of untreated subjects during the late mixed dentition stage.

Methods: The cross-sectional study was conducted over three years starting March 2013 at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia, and comprised consecutive models taken annually of subjects seeking dental treatment. They were aged 9 years at baseline and dimensional changes were calculated at 9, 10 and 11 years of age. Measurements taken each year were overjet, overbite; inter-canine width, canine length, inter-first deciduous molar width, inter-first premolar width, inter-first permanent molar width, arch length, molar depth, incisor irregularity, and available anterior space. SPSS 16 was used for data analysis.

Results: Of the 15 subjects, 10(66.6%) were girls and 5(33.3%) were boys. Of all the variables, the mean values of overbite (p=0.006) and inter-canine width (p=0.001) increased significantly over the period, while the mean irregularity index values decreased significantly (p<0.0001).

Conclusions: An increase in overbite and inter-canine width, and a reduction in the irregularity index of teeth was detected during the mixed dentition phase.

Keywords: Dental arch, Inter-canine width, Mixed dentition, Orthodontic intervention. (JPMA 69: 77; 2019)

Introduction

It is well known that minor mal-alignment of the lower incisors in the mixed dentition phase is considered a normal developmental process. This problem usually resolves by a combination of a slight increase in the inter-canine width, labial positioning of the permanent incisors relative to the primary incisors, and slight backward movement of the canines into the primate space.[1] It is estimated that the mean crowding of the lower incisors reduces approximately 0.9mm from the initial eruption of the lower permanent incisors to the initial eruption of the permanent canines.[2] When crowding is of a greater magnitude, correction by normal development may not occur and early intervention might be required. A study showed that approximately 90% children with crowding in the early mixed dentition phase continued to display crowding in the permanent dentition, and that those who self-corrected had only 0.5mm of mal-alignment in the early mixed dentition phase.[3] A team studied changes in arch length longitudinally from 6 weeks to 45 years of age and reported that the greatest incremental increase in arch length took place during the first two years of life. Thereafter, an increase in arch length in the mandible occurred only until 8 years of age, while the maxilla continued until 13 years of age.[4]

The contributing factors leading to this crowding are many and include reduced arch length, reduced arch dimension, and the presence of large-sized teeth. In a study, significant difference in arch dimension was found between subjects with and subjects without crowding.[5] A study reported that the maxillary and mandibular arch lengths, and the mesiodistal size of the primary canines were all factors that could lead to crowding in the incisor region.[6] Another study also concluded that the larger the mesiodistal width of the mandibular incisors, the greater was the crowding.[7] On the other hand, a study examined 230 male subjects and found little variation between tooth diameter of subjects with and without crowding.[8]

Determining the causal factors that contribute to the development of lower incisor crowding in the mixed dentition is essential. This will aid in differentiating those who will develop future deficiencies in space and, hence, require orthodontic treatment, and those who might self-correct. Longitudinal studies are useful in these cases because they provide information on the different stages of development of the dentition and how crowding develops.

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The current study was planned to evaluate the dimensional changes that occurred in the mandibular arch over a three-year period from 9 to 11 years of age.

Subjects and Methods

The cross-sectional study was conducted over three years starting March 2013 at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia, and comprised consecutive models taken annually of subjects seeking dental treatment. They were aged 9years at baseline, and dimensional changes were calculated at ages 9, 10 and 11.

- Those enrolled from the paediatric dental clinic were in late mixed dentition stage (fully erupted four permanent mandibular incisors, deciduous canines, deciduous molars, and permanent first molars); Class I molar and canine relation (permanent or primary canines); crowding (mild, moderate, or severe) in the lower anterior segment; good oral hygiene; no previous orthodontic treatment; and no craniofacial deformity.

- Those with congenitally missing permanent teeth, premature loss of deciduous or permanent teeth, patients with extensive caries or attrition affecting the tooth dimension were excluded.

Approval was obtained from the institutional ethics committee and informed written consent was taken from the parent of each subject.

Alginate impressions were taken and study models were constructed for each child at the baseline. Due to difficulty in the follow-up of these patients, cancellation of appointments, no show or no answer, the total number of children who could be followed over the three-year study period represented the final sample. Impressions were taken and study models constructed annually at each follow-up appointment.

To determine the lower arch changes that occurred during the study period, measurements were made on each study model by the use of an electronic digital caliper (Mitutoyo America Corporation, Aurora, Illinois, USA) to the accuracy of 0.01mm. Ten measurements concerning dental arch development were performed as follows. The included Overjet (OJ), which is the distance in millimeters (parallel to the occlusal plane) from the most labial aspect of the maxillary central incisor to the most labial aspect of the mandibular central incisor;[9] overbite (OB), which is the percentage of the mandibular central incisors overlapped by the maxillary central incisors;[9] mandibular inter-canine width, which is the distance in millimeters between cusp tips or estimated cusp tips in cases of wear facets if primary canines are present;[9] canine length, which is the perpendicular distance from the contact point of the central incisors to the inter-canine width;[10] mandibular inter-first premolar/deciduous molar width which is the distance in millimeters between buccal cusp tips or estimated cusp tips in cases of wear facets;[9] mandibular inter-first permanent molar width, which is the distance in millimeters from the buccal cusp tips of the mandibular permanent first molars,[9] mandibular arch length, which is the sum of the right and left distances (R&L) in millimeters from mesial anatomic contact points of the first permanent molars to the contact point of the central incisors or the midpoint between the central incisors;[9] molar depth, which is the perpendicular distance from the contact point of the central incisors to the line joining the mesial contact areas of 1st permanent molars;[11] mandibular incisor irregularity index, which is the summed displacement of the anatomic contact points of the mandibular anterior teeth in millimeters;[9] mandibular anterior space analysis, which is the sum of the mesiodistal widths of the mandibular teeth from canine to canine subtracted from the space available, which is measured from the contact point of the canine and the first premolar/ deciduous molar in millimeters;[9] arch depth at mandibular lateral incisors, which is the mean of the perpendicular distance from the incisal edges of the lateral incisors to the line joining the mesial contact areas of 1st permanent molars (Figure-1).

All measurements were performed by a single investigator. Before starting the measurements, a reliability test was performed by re-measuring 14 casts (from 8 cases with a total of 121 measurements) twice over a period of 2 weeks. The correlation coefficient and the Cronbach's alpha both showed a high correlation between the first and second readings (0.9957 and 0.9978

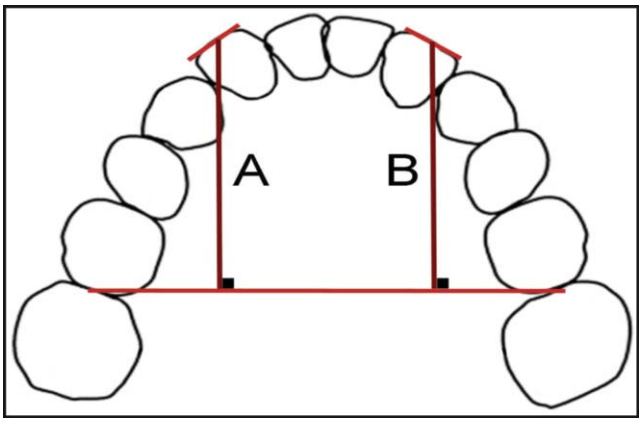

Figure-1: Arch depth at the mandibular lateral incisors is calculated as the mean of: the perpendicular distance from the incisal edge of the left lateral incisor (A), and the perpendicular distance from the incisal edge of the right lateral incisor (B) to the line joining the mesial contact areas of the 1st permanent molars.

respectively).

Data was analysed using SPSS version 16.0 (SPSS Inc, Chicago, Illinois, USA. Descriptive statistics were used for the outcome variables. Repeated one-way analysis of variance (ANOVA) was used to compare the repeated mean values of quantitative variables at the three stages of observation followed by post-hoc test using Bonferroni correction. Non-parametric Friedman test was used to compare the repeated values of the skewed data. P<0.05 was considered statistically significant.

Results

Initially, 75 subjects were enrolled, but only 15(20%) completed the study. Of them, 10(66.6%) were girls and 5(33.3%) were boys. Overbite and the arch depth at the lateral incisors significantly increased with time (p<0.05 each), while the irregularity index decreased significantly (p<0.05). Mean OB values at the 1st and the 2nd stages (p=0.040), and at the 1st and the 3rd stages (p=0.022) were statistically different, but were not significantly different between the 2nd and the 3rd stages (p=0.88). Mean inter-canine width values at the 1st and the 3rd stages (p=0.002), and at the 2nd and 3rd stages (p=0.001) were statistically different, but were not different at the 1st and the 2nd stages (p=0.154). Mean arch depth at the

Table-1: Comparison of the mean values of the study variables between the three stages.

Variables	1st Stage (T1)		2nd Stage (T2)		3rd Stage (T3)		F-value* / chi-square value**	p-value
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	9.03	0.34	10.17	0.32	11.12	0.38	832.7	<0.0001‡
OJ (mm)	4.20	2.51	4.33	1.98	4.43	2.06	0.29	0.62
OB (%)	24.33	25.35	36.33	22.40	42.50	26.87	8.96	0.006‡
Inter-Canine Width (mm)	25.37	1.92	26.20	1.50	25.67	2.01	18.8	0.001‡
Canine Length (mm)	4.63	1.30	4.92	1.16	5.44	0.82	2.6	0.14
Inter-D-Width (mm)	31.57	2.28	32.54	1.81	32.76	0.50	0.097	0.81
Inter-4-Width (mm)	33.29	3.13	33.43	2.20	34.01	1.47	0.10	0.80
Inter-Molar Width (mm)	42.17	2.33	42.36	2.50	42.58	2.66	0.53	0.49
Arch Length (mm)	64.10	3.34	63.86	3.81	63.58	4.23	1.37	0.27
Molar Depth (mm)	24.10	1.96	24.07	2.21	23.89	2.45	0.51	0.56
Irregularity Index	9.41	2.52	6.07	2.93	4.39	1.84	29.4	<0.0001‡
Anterior Space Analysis**	-1.95	2.05	-1.54	3.38	-2.08	15.48	1.13**	0.57
Arch Depth at laterals (mm)	20.68	2.37	21.40	2.28	21.36	2.32	9.91	0.005‡

*Repeated measures analysis of variance; **Friedman test; ‡Statistically significant.
OJ: Overjet. OB: Overbite.

Table-2: The changes in the Irregularity Index and the arch depth at the lateral incisors between the three stages in each case (differences between the stages: T1, T2, and T3).

Case #	Irregularity Index T1-T2	Arch Depth at the laterals T1-T2	Irregularity Index T2-T3	Arch Depth at the laterals T2-T3	Irregularity Index T1-T3	Arch Depth at the laterals T1-T3
1	-1.80	-0.25	-1.00	-1.00	-2.80	-1.25
2	-9.25*	0.50	-0.25*	0.25	-9.50*	0.75
3	-7.40*	0.50	2.80	0.25	-4.60	0.75
4	-5.10	1.50	-1.50	0.00	-6.60	1.50
5	-2.20	1.25	-0.50	0.25	-2.70	1.50
6	-3.70*	0.00	0.70	-1.00	-3.00	-1.00
7	0.00	0.00	-6.00	-0.25	-6.00	-0.25
8	-6.50*	1.00	-	-	-	-
9	-4.70	0.75	-0.80	-0.25	-5.50	0.50
10	-2.00	1.00	-2.00*	0.50	-4.00*	1.50
11	-2.00	0.50	-1.70*	0.25	-3.70*	0.75
12	0.20	0.75	-5.70*	0.00	-5.50*	0.75
13	-2.90	1.00	-1.90*	0.50	-4.80*	1.50
14	-0.30	1.00	-4.00*	0.00	-4.30*	1.00
15	-2.50	1.25	-0.50*	0.00	-3.00*	1.25
Mean ± SD	-3.34 ± 2.772	0.72 ± 0.508	-1.60 ± 2.355	-0.04 ± 0.469	-4.71 ± 1.854	0.66 ± 0.902

*Missing one or both canines.

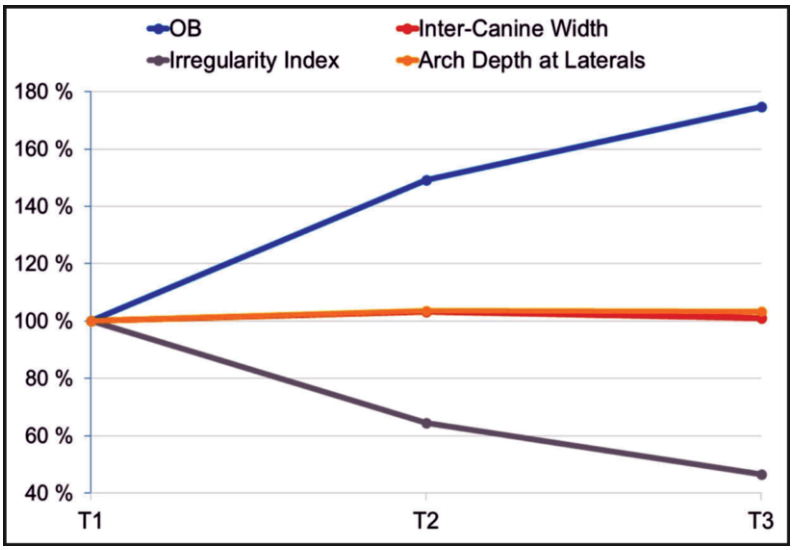

Figure-2: Changes in percentage of the overbite (OB), inter-canine width, arch depth at the lateral incisors, and the Irregularity Index in the 2nd (T2) and 3rd (T3) stages.

lateral incisors as statistically different at the 1st and 2nd stages (p=0.001). Mean irregularity index values decreased significantly across the three stages (p<0.05 each) (Table-1). The changes were also calculated in percentage terms (Figure-2).

The greatest reduction in the mean irregularity index occurred between the 1st and 2nd stage (-3.34), and it continued to decrease between the 2nd and 3rd stage (-1.60). The labial movement of the lateral incisors leading to the increase in arch depth mean values between the stages contributed to the reduction in the irregularity index. At the end of the study period, the mandibular incisors moved labially at a mean value of 0.66±0.902mm. The exfoliation of the primary canines also contributed to the reduction in the Irregularity index as shown in some cases.

Discussion

One of the most difficult aspects while conducting longitudinal studies is to acquire as many subjects as possible. Several hindering factors exist including the limited number of qualified subjects, the dropout rate of patients, and the attainment of proper records throughout the follow-up period. A large sample is an ideal setting for any study, but due to the challenges mentioned above, the sample size for the current study was reduced. Nonetheless, it was still possible to draw some conclusions from the results.

When OB was examined, an increase was evident from the first stage (9-year old) to the third stage (11-year old). This is in agreement with a study conducted in a sample of Turkish children in the mixed dentitionphase,[12] and another which also found that OB increasedin the early years of transition from 7-12 years of age.[13] The same pattern was observed between the pre-pubertal and the beginning of puberty stages in a study that was based on records of growth studies.[14] Earlier studies reported similar significant increase in the OB towards the permanent dentition stage followed by a decrease into the adulthood stage.[15-17] It was claimed that OB tends to increase in the mixed dentition phase due to the mesial drift of the first permanent molars into the leeway space and the possible closure of the occlusion.[12]

In the current study, the inter-canine width was also found to increase from the age of 9 years to 11 years of approximately 0.9mm, then it decreased slightly. This is similar to the findings of a study which found an increase in inter-canine width until the eruption of the permanent canines.[4,18,19] Other studies also reported similar findings with regards to the increase in the inter-canine width to the age of 10 years, but a continuous decrease was found between 16 and 31 years of age.[20] A possible explanation of the early increase in the inter-canine width is that during the permanent incisors eruption, a lateral force is exerted on the roots of the neighbouring primary teeth. This lateral force pushes the primary lateral incisors into the primary canines, increasing inter-canine width.[21,22] The same occurred as the permanent lateral incisors erupted, which in turn forced the primary canines laterally, increasing the inter-canine width. Children with mild crowding in the incisor region will benefit from this increase and may not need treatment at that time other than just observation during the eruption process.[23] A study examined dental casts of 54 Swedish children at the ages of 7, 9, 10 and 14 years and concluded that crowding occurred more frequently when the inter-canine distance was reduced (<26mm), while subjects with a large inter-canine distance (>28mm) had no risk of crowding.[24]

On the other hand, one study concluded that inter-canine width, molar arch width, and arch depth were unreliable predictors of either incisor or canine crowding changes.[11]

The irregularity index decreased significantly across three stages of growth in the current study. It is well known that the index measures how far the proximal contacts are away from each other. The results of the present study showed a significant reduction in this index as the subjects grew. A study reported insignificant reduction in

the index.[12] Another observational study suggested that there was a considerable crowding among the sample between 9 and 10 years of age where the permanent canine erupted and it reported that crowding was decreased between ages 12 and 14, and it increased again from 14 to 18 years of age.[16] Our findings might be related to distalisation of incisors and canine to leeway space or to facial growth, since mal-alignment has multifactorial aetiology and it has been suggested that the position of the incisors might be correlated with the amount and direction of growth.[25]

When arch dimensions were evaluated in the current study, there were no significant findings in the three stages of development. A study reported an increase in inter-first premolar width, inter-molar width and an insignificant decrease in arch length and no change in arch depth.[12] Another study reported an increase in the inter-first permanent molar width[13] while another reported an increase in the inter-first permanent molar width among males and no change in females.[26] Regarding arch length, several studies have reported a decrease in their respective samples.[16,27,28] The explanation to these contrary results is differences in sample selection, sample size, and differences in the reference points used to measure the studied variables.

Conclusion

During the mixed dentition phase an increase in overbite and inter-canine width, and a reduction in the irregularity index of teeth, was detected. Orthodontic intervention to relieve mandibular incisor crowding during this phase may not be required since the crowding might be self-correct.

Disclaimer: None.

Conflict of Interest: None.

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