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Alveolar Growth in Japanese Infants: A Comparison between Now and 40 Years ago

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Abstract

To investigate differences in alveolar growth during the primary dentition period among different age groups, dental arch width, length, and height were measured in 93 dental arch plaster models obtained from 4-year-olds born between 1968 and 1974, 88 from 5-year-olds born between 1968 and 1974 (70s group), 61 from 4-year-olds born between 2007 and 2009, and 56 from 5-year-olds born between 2006 and 2008 (2000s group). A comparison was also performed to determine whether there was any difference in change between 4 and 5 years of age. The results showed age- and sex-dependent differences in growth patterns in primary dental arch width, length, and height. The amount of change was greater in the 2000s group than in the 70s group, suggesting that yearly growth between 4 and 5 years of age has increased over the last 40 years.

Key words: Infants — Deciduous dentition — Development — Growth — Dental casts

Introduction

The basic shape of the primary teeth remains largely unaltered throughout development, so little change occurs in the morphology of the crown compared with in the permanent teeth. Likewise, the primary dentition is less affected by environmental factors than the permanent dentition, again resulting in only minor change in morphology.

On the other hand, some major changes, such as in diet, for example, can affect the physical and mental development of a child. Dietary disturbances are known to have an adverse effect on oral conditions, with one study on the influence of change in diet in the Kingdom of Tonga noting the development of dental caries and periodontal disease[2)]. In 1993, the Japanese Society of Pediatric Dentistry reported change in the width of the deciduous crown and dental arch based on measurements of dental arch plaster models obtained from patients at 2 years and 6 months and 5 years and 11 months as reference values[3)].

The purpose of this study was to investigate

change in jaw and tooth size during the primary dentition period by analyzing 93 dental arch plaster models obtained from 4-year-olds born between 1968 and 1974 and 61 models from 4-year-olds born in 2009. The results revealed greater mesiodistal crown width in most of the teeth and a tendency toward a reduction in dental arch width, length, and height in the primary dentition of present-day infants compared with in those investigated approximately 40 years ago by the 30th Conference of the Japanese Society of Pediatric Dentistry in the Kanto area. A total of 88 dental arch plaster models of 5-year-olds born between 1968 and 1974 and 56 models of 5-year-olds born between 2006 and 2008 were also compared with previously reported dental arch plaster models obtained from 4-year-olds to elucidate differences in alveolar growth from 4 to 5 years of age.

Materials and Methods

1. Materials

1) Group born between 1968 and 1974 (70s group)

Dental arch plaster models obtained from patients born between 1968 and 1974 (70s group) and attending our department were used. The clinical occlusal relationship in these models showed normal primary dentition when the first impression was taken. Impressions were then taken every 2 months with the agreement of the patient and guardian. In total, 93 plaster models comprising 45 obtained from boys aged 4 years 6 months and 48 from girls aged 4 years 4 months, and 88 further models comprising 40 from boys and 48 from girls aged 4 years 4 months were examined. There were no fractures in the models, and no caries or restoration work that might have affected the measurements.

2) Group born between 2007 and 2009 or between 2006 and 2008 (2000s group)

The 2000s group comprised models obtained from children born between 2007 and 2009 or between 2006 and 2008. The clinical occlusal relationship in these models of the dental arch showed normal primary dentition. In total, 61 plaster models comprising 25 obtained from boys aged 4 years (mean age, 4 years 5 months) and 36 from girls aged 4 years (mean age, 4 years 4 months), and 56 further models comprising 26 from boys aged 5 years (mean age, 5 years 6 months) and 30 from girls aged 5 years (mean age, 5 years 6 months) were examined. There were no fractures in the models, and no caries or restoration work that might have affected the measurements.

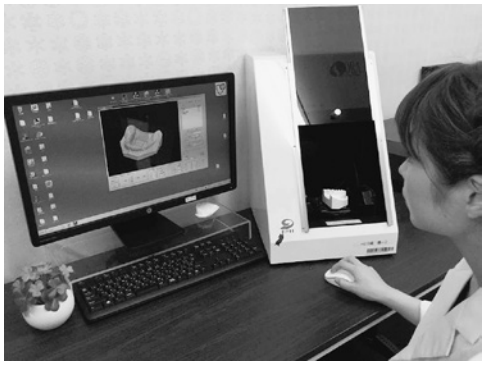

Fig. 1 3-D measurement system

2. Study method

1) Measurement method

A system capable of 3-dimensional (3-D) measurement (DORA®) (3D! Co., Ltd.) was used. This system allows measurement to an accuracy of 10 to 30 μm. Undercuts and areas that are difficult to measure can be enlarged and sectioned on CAD for more accurate measurements. The precision of this system was reported by Arakawa *et al.*[1] in 2015. After using this system to measure similar models, Kaihara *et al.*[4] reported that its accuracy was as good as that available with a caliper. In the present study, the same experienced technician installed the models and performed the measurements (Fig. 1).

2) Measurement area

Figure 2 shows the areas measured, which comprised the dental arch width (6 measurements for each jaw), length (3 measurements

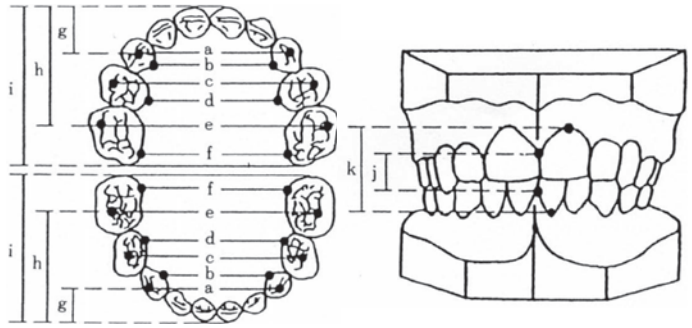

Fig. 2 Measurement areas of dental arch

Dental arch width

a: Distance between maxillary and mandibular bilateral canine cusps (C_C-C_C)

b: Distance between lowest points in cervical area of palatal (lingual) side of maxillary and mandibular primary canines (C_L-C_L)

c: Distance between buccal cusps of maxillary bilateral primary molars (D-D)
Distance between buccal terminal sulcus of mandibular bilateral first primary molars (D-D)

d: Distance between lowest points in cervical area of palatal side of maxillary bilateral primary molars (D_L-D_L)
Distance between sub-lingual sulcus points of lingual mesiodistal cusps of mandibular bilateral first primary molars (D_L-D_L)

e: Distance between buccal terminal sulcus of maxillary bilateral second primary molars (E-E)
Distance between mesial buccal terminal sulcus of mandibular bilateral second primary molars (E-E)

f: Distance between lowest points in cervical area of palatal (lingual) side of maxillary and mandibular bilateral second primary molars (E_L-E_L)

Dental arch length

g: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to bilateral primary canine cusps (A-C_C)

h: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to mesial buccal terminal sulcus of bilateral second primary molars (A-E)

i: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to most distal edges of bilateral second primary molars (A-E_D)

Dental arch height

j: Distance between interdental papillae of maxillary and mandibular bilateral primary central incisors (Dental Height)

k: Distance between center in cervical area of labial surface of maxillary and mandibular left primary central incisors (ULA-LLA)

for each jaw), and height (2 measurements), in line with the measurement criteria of the Japanese Society of Pediatric Dentistry survey published in 1993[3].

3) Statistics

Differences in the population mean test (*t*-test) of dental arch width, length, and height were used to compare 4- and 5-year-olds in the 70s group, and 4- and 5-year-olds in the 2000s group. Alveolar growth between 4 and 5 years of age was evaluated in each group and inter-group comparisons performed. Differences in average alveolar growth from 4 to 5 years of age were expressed as absolute values in order to obtain a clearer picture of differences in amount of change between

generations.

The present study was approved by the Ethics Committee of Tokyo Dental College (Approval no: 295).

Results

1. Growth in 70s group

Table 1 shows the mean, standard deviation, and difference in obtained values for dental arch width, length, and height in each sex in the 70s group between 4 and 5 years of age; it also shows whether the difference was significant between 4 and 5 years of age.

In boys, dental arch width showed an increase at all points measured in both the maxilla and mandible, with mandibular D-D, in particular, showing a significant increase ($p<0.05$). Although there was no significant difference in dental arch length, A-E_D showed an increase in the maxilla and mandible, whereas other areas showed a decrease. Dental arch height showed a significant increase ($p<0.05$) in both areas measured.

In girls, dental arch width showed an increase in the maxilla, except at E-E, none of these values were significant, however. There were little values changes in the mandible. The results for dental arch length differed from those for dental arch width, with all measurements showing little changes in the maxilla, and an increase in the mandible. Both measurements of dental arch height showed a decrease.

2. Growth in 2000s group

Table 2 shows the average, standard deviation, and difference in obtained values for dental arch width, length, and height in each sex in the 2000s group between 4 and 5 years of age; it also shows differences between 4 and 5 years of age. None of the measurements showed a significant difference in either sex.

In terms of dental arch width in boys, all the measurements showed an increase in the maxilla. Although E-E and E_L-E_L showed an increase in the mandible, the other measurements showed a decrease. Dental arch length between A-C_C showed a decrease in both the maxilla and the mandible, whereas the other measurements showed an increase. Dental arch height showed a decrease in both measurements.

In terms of dental arch width in girls, C_C-C_C and D_L-D_L showed a decrease in the maxilla, whereas the other measurements showed an increase. In the mandible, D_L-D_L and E_L-E_L showed a decrease, whereas the other measurements showed an increase. Although there was no significant difference in dental arch length, and A-C_C showed a decrease, the other measurements showed an increase in the maxilla. No significant difference was observed in dental arch height, but both measurements showed an increase.

3. Comparison of dental arch growth between age groups

Tables 1 and 2 show differences between 4 and 5 years of age in primary dental arch width, length, and height.

Width showed an increase, whereas length showed a decrease in the 70s group. Height showed an increase in boys but a decrease in girls (Table 1). Although width showed an increase in the 2000s group, length showed a decrease in the anterior and increase in the posterior. Height showed a decrease in boys and an increase in girls in the 2000s group, which was the opposite of in the 70s group (Table 2).

Absolute values for differences in measurements between 4 and 5 years of age in the 70s and 2000s groups were used to compare amount of growth. Change in growth was greater in most measurements of dental arch width (Table 3), length (Table 4), and height (Table 5) in the 2000s group compared with in the 70s group.

Discussion

1. Growth in 70s group

Primary dental arch width showed an increase in all measurements in both the maxilla and mandible in boys between 4 and 5

Table 1 Growth of the dental arch in the 70s group

Measurement area	Boys		Age difference	Girls		Age difference
	Mean ± SD (mm)			Mean ± SD (mm)		
	4 years old	5 years old		4 years old	5 years old	
Dental arch width						
Maxilla						
C_C-C_C	30.93 ± 1.54	31.40 ± 1.52		29.63 ± 1.72	29.64 ± 1.74	
C_L-C_L	25.49 ± 1.39	25.60 ± 1.33		24.23 ± 1.64	24.26 ± 1.68	
D-D	39.71 ± 2.02	40.17 ± 1.68		38.07 ± 1.85	38.09 ± 1.86	
D_L-D_L	28.18 ± 1.35	28.46 ± 1.29		26.73 ± 1.72	26.74 ± 1.73	
E-E	47.26 ± 1.85	47.52 ± 1.56		45.19 ± 1.76	45.18 ± 1.75	
E_L-E_L	30.59 ± 1.40	30.96 ± 1.35		28.99 ± 1.72	28.99 ± 1.72	
Mandible						
C_C-C_C	23.61 ± 1.66	23.74 ± 1.96		22.68 ± 1.56	22.70 ± 1.54	
C_L-C_L	19.57 ± 1.30	20.03 ± 1.45		18.77 ± 1.26	18.77 ± 1.25	
D-D	31.10 ± 1.72	32.28 ± 2.74	*	30.20 ± 1.92	30.20 ± 1.92	
D_L-D_L	25.14 ± 1.30	25.35 ± 1.18		24.31 ± 1.58	24.31 ± 1.58	
E-E	40.05 ± 1.78	40.17 ± 1.59		38.62 ± 1.72	38.62 ± 1.71	
E_L-E_L	29.28 ± 1.25	29.68 ± 1.33		28.39 ± 1.49	28.38 ± 1.47	
Dental arch length						
Maxilla						
A-C_C	7.98 ± 0.84	7.97 ± 1.02		8.11 ± 0.74	8.11 ± 0.74	
A-E	23.33 ± 1.42	23.18 ± 1.30		22.95 ± 1.30	22.94 ± 1.30	
A-E_D	29.11 ± 1.48	29.28 ± 1.98		28.80 ± 1.25	28.80 ± 1.25	
Mandible						
A-C_C	5.46 ± 0.68	5.26 ± 0.69		5.68 ± 0.55	5.69 ± 0.57	
A-E	20.04 ± 1.23	19.77 ± 1.34		19.96 ± 0.99	20.02 ± 0.99	
A-E_D	26.57 ± 1.43	26.85 ± 3.98		26.10 ± 1.12	26.18 ± 1.12	
Dental arch height						
Dental Height	3.16 ± 1.43	4.03 ± 1.66	*	3.28 ± 1.48	3.26 ± 1.49	
ULA-LLA	7.61 ± 1.64	8.40 ± 1.86	*	7.60 ± 1.55	7.59 ± 1.54	

*$p<0.05$

C_C-C_C: Distance between bilateral canine cusps
C_L-C_L: Distance between lowest points in cervical area of palatal (lingual) side of primary canines
D-D: Distance between buccal cusps of maxillary bilateral primary molars
Distance between buccal terminal sulcus of mandibular bilateral first primary molars
D_L-D_L: Distance between lowest points in cervical area of palatal side of maxillary bilateral primary molars
Distance between sub-lingual sulcus points of lingual mesiodistal cusps of mandibular bilateral first primary molars
E-E: Distance between buccal terminal sulcus of maxillary bilateral second primary molars
Distance between mesial buccal terminal sulcus of mandibular bilateral second primary molars
E_L-E_L: Distance between lowest points in cervical area of palatal (lingual) side of maxillary and mandibular bilateral second primary molars
A-C_C: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to bilateral primary canine cusps
A-E: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to mesial buccal terminal sulcus of bilateral second primary molars
A-E_D: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to most distal edges of bilateral second primary molars
Dental Height: Distance between interdental papillae of maxillary and mandibular bilateral primary central incisors
ULA-LLA: Distance between center in cervical area of labial surface of maxillary and mandibular left primary central incisors

Table 2 Growth of the dental arch in the 2000s group

Measurement area	Boys		Age difference	Girls		Age difference
	Mean ± SD (mm)			Mean ± SD (mm)		
	4 years old	5 years old		4 years old	5 years old	
Dental arch width						
Maxilla						
C_C-C_C	30.13 ± 2.33	31.08 ± 1.52		30.13 ± 1.36	29.96 ± 1.55	
C_L-C_L	24.80 ± 1.78	24.98 ± 1.20		24.20 ± 1.23	24.38 ± 1.58	
D-D	39.53 ± 1.92	39.81 ± 1.61		38.64 ± 1.62	39.00 ± 1.96	
D_L-D_L	27.54 ± 1.49	27.86 ± 1.29		26.95 ± 1.38	26.81 ± 1.77	
E-E	46.47 ± 2.32	47.29 ± 1.75		45.59 ± 1.53	46.04 ± 2.08	
E_L-E_L	30.03 ± 1.64	30.37 ± 1.52		29.17 ± 1.25	29.27 ± 1.77	
Mandible						
C_C-C_C	23.09 ± 2.04	22.97 ± 1.55		22.43 ± 1.52	22.73 ± 1.91	
C_L-C_L	19.49 ± 1.59	19.23 ± 1.45		18.55 ± 0.99	18.71 ± 1.62	
D-D	33.77 ± 1.84	33.60 ± 2.08		32.85 ± 1.33	33.17 ± 2.11	
D_L-D_L	24.63 ± 1.43	24.35 ± 1.44		23.74 ± 1.24	23.50 ± 1.69	
E-E	39.54 ± 2.52	39.79 ± 1.95		38.20 ± 1.37	38.62 ± 2.13	
E_L-E_L	28.82 ± 1.46	29.06 ± 1.81		27.76 ± 1.38	27.66 ± 1.64	
Dental arch length						
Maxilla						
A-C_C	8.55 ± 1.08	8.46 ± 1.11		8.42 ± 1.14	8.34 ± 1.03	
A-E	22.75 ± 1.34	22.96 ± 1.29		22.52 ± 1.31	23.34 ± 4.78	
A-E_D	28.36 ± 1.24	29.22 ± 2.73		28.32 ± 1.43	28.69 ± 2.38	
Mandible						
A-C_C	5.45 ± 0.95	5.20 ± 0.72		5.68 ± 0.71	6.02 ± 0.93	
A-E	20.34 ± 3.71	21.11 ± 6.45		19.73 ± 1.10	20.51 ± 3.77	
A-E_D	26.04 ± 0.96	26.21 ± 1.34		25.89 ± 1.31	26.38 ± 1.53	
Dental arch height						
Dental Height	4.26 ± 1.08	4.16 ± 0.92		3.69 ± 1.35	4.32 ± 1.86	
ULA-LLA	8.49 ± 1.12	8.11 ± 0.87		7.95 ± 1.33	8.49 ± 2.00	

C_C-C_C: Distance between bilateral canine cusps
C_L-C_L: Distance between lowest points in cervical area of palatal (lingual) side of primary canines
D-D: Distance between buccal cusps of maxillary bilateral primary molars
Distance between buccal terminal sulcus of mandibular bilateral first primary molars
D_L-D_L: Distance between lowest points in cervical area of palatal side of maxillary bilateral primary molars
Distance between sub-lingual sulcus points of lingual mesiodistal cusps of mandibular bilateral first primary molars
E-E: Distance between buccal terminal sulcus of maxillary bilateral second primary molars
Distance between mesial buccal terminal sulcus of mandibular bilateral second primary molars
E_L-E_L: Distance between lowest points in cervical area of palatal (lingual) side of maxillary and mandiblular bilateral second primary molars
A-C_C: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to bilateral primary canine cusps
A-E: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to mesial buccal terminal sulcus of bilateral second primary molars
A-E_D: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to most distal edges of bilateral second primary molars
Dental Height: Distance between interdental papillae of maxillary and mandibular bilateral primary central incisors
ULA-LLA: Distance between center in cervical area of labial surface of maxillary and mandibular left primary central incisors

Table 3 Age difference in the growth of the dental arch width

Measurement area	Difference in the dental arch width (Absolute value mm)											
	C_C-C_C		C_L-C_L		D-D		D_L-D_L		E-E		E_L-E_L	
Age	70s group	2000s group	70s group	2000s group	70s group	2000s group	70s group	2000s group	70s group	2000s group	70s group	2000s group
Boys												
Maxilla	0.47	0.94	0.12	0.18	0.46	0.28	0.28	0.32	0.26	0.82	0.37	0.34
Mandible	0.14	0.12	0.46	0.26	1.18	0.17	0.21	0.28	0.12	0.25	0.40	0.24
Girls												
Maxilla	0.02	0.17	0.03	0.19	0.01	0.35	0.01	0.14	0.01	0.45	0.00	0.10
Mandible	0.02	0.29	0.01	0.16	0.00	0.32	0.00	0.25	0.01	0.42	0.01	0.11

C_C-C_C: Distance between bilateral canine cusps
C_L-C_L: Distance between lowest points in cervical area of palatal (lingual) side of primary canines
D-D: Distance between buccal cusps of maxillary bilateral primary molars
Distance between buccal terminal sulcus of mandibular bilateral first primary molars
D_L-D_L: Distance between lowest points in cervical area of palatal side of maxillary bilateral primary molars
Distance between sub-lingual sulcus points of lingual mesiodistal cusps of mandibular bilateral first primary molars
E-E: Distance between buccal terminal sulcus of maxillary bilateral second primary molars
Distance between mesial buccal terminal sulcus of mandibular bilateral second primary molars
E_L-E_L: Distance between lowest points in cervical area of palatal (lingual) side of maxillary and mandibular bilateral second primary molars

years of age. In a study using 28 longitudinal plaster models obtained from the same subjects between 3 and 20 years of age, Tsujino and Machida[6] reported that primary dental arch width showed a slight increase, but was relatively stable until 6 years of age, after which it showed a gradual increase during the incisor eruption period. Similar results were observed in the present study, with little change between 4 and 5 years of age, and a statistically significant increase only occurring in mandibular D-D. We believe that this may have been due to lateral growth as a preparation for incisor exchange. In terms of dental arch length, A-E_D showed an increase in both the maxilla and the mandible, but a decrease in other measurements. These results were similar to those of an earlier report by the Japanese Society of Pediatric Dentistry in 1993[3]. This may have been due to the fact that the interdental space decreased due to intraosseous eruption of the first molar, resulting in a decrease in all measurements other than A-E_D. However, we believe that the increase in A-E_D observed here may have been due to the greater extent of change in the most distal end of the distal proximal surface of the second primary molar. These changes between 4 and 5 years of age were not statistically significant.

The primary dental arch height showed a significant increase in both measurements, as was observed in the above-mentioned report by the Japanese Society of Pediatric Dentistry[3]. This may have been due to vertical growth of the alveolar bone of the incisor during its intraosseous eruption. One earlier study by Shimomura *et al.*[5] evaluated vertical growth of the maxilla and mandible using cephalograms obtained from 3- to 5-year-old children with anterior crossbite during the primary dentition period. They also observed vertical growth, as in the present study.

In contrast, in the present study, dental arch width growth between 4 and 5 years of age differed between girls and boys. In girls,

Table 4 Age difference in the growth of dental arch length

Measurement area	Difference in the dental arch length (Absolute value mm)					
	A-C_C		A-E		A-E_D	
Age	70s group	2000s group	70s group	2000s group	70s group	2000s group
Boys						
Maxilla	0.01	0.09	0.15	0.22	0.17	0.86
Mandible	0.20	0.25	0.27	0.77	0.28	0.17
Girls						
Maxilla	0.00	0.07	0.02	0.82	0.01	0.37
Mandible	0.01	0.34	0.07	0.78	0.08	0.49

A-C_C: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to bilateral primary canine cusps
A-E: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to mesial buccal terminal sulcus of bilateral second primary molars
A-E_D: Length of perpendicular line from center of line connecting labial surface of bilateral primary central incisors to most distal edges of bilateral second primary molars

an increase was observed in the maxilla, except for at E-E. These results in the maxilla were considered to be due to lateral growth prior to incisor exchange, as reported by Tsujino and Machida[6], and positional change in the buccal terminal sulcus of the second primary molar with intraosseous eruption of the first molar. However, the 1993 report of the Japanese Society of Pediatric Dentistry[3] demonstrated completely opposite results in the mandible, including a decrease in C_C-C_C and an increase in other measurements. The increase in C_C-C_C observed in girls in the present study may have been due to preparation for incisor exchange. The models for the study of the 70s group were obtained from the same individuals. Therefore, the results were different from the report in 1993[3], which used cross-sectional models. In the present study, dental arch length showed a decrease in all measurements in the maxilla, and an increase in all measurements in the mandible. Although the results for the maxilla were similar to those of the 1993 report[3], those for the mandible showed a decrease in all measurements, which was completely the opposite from those of that earlier report. This may have been because the interdental space decreased due to intraosseous eruption of the first molar in the maxilla, as in boys. Differences in the study methodology used may also have influenced the outcome. Dental arch height showed a decrease in both measurements, which coincides with the results of the 1993 study[3]. Since the incisors erupt earlier in girls than boys, dental attrition of the primary teeth affects more than the vertical growth of alveolar bone due to intraosseous eruption of the incisors. However, these changes between 4 and 5 years of age in girls were not statistically significant.

2. Growth in 2000s group

Primary dental arch width in boys showed an increase in the maxilla both anteriorly and posteriorly, whereas an increase was only seen in the posterior dentition in the mandible, with a decrease anteriorly. These results differed from those of the 1993 report[3], which showed an increase in all measurements, and those of the report by Tsujino and Machida[6], which showed an increase in width between primary canines during the incisor exchange period. Tsujino and Machida used longitudinal plaster models obtained from the same subjects[6]. In the present study, however, the

Table 5 Age difference in the dental arch height growth

	Difference in the dental arch height (Absolute value mm)			
Measurement area	Dental Height		ULA-LLA	
Age	70s group	2000s group	70s group	2000s group
Boys	0.87	0.10	0.79	0.38
Girls	0.02	0.63	0.01	0.53

Dental Height: Distance between interdental papillae of maxillary and mandibular bilateral primary central incisors
ULA-LLA: Distance between center in cervical area of labial surface of maxillary and mandibular left primary central incisors

samples in the 2000s group were cross-sectional, as in the 1993 report, which suggests a difference in growth pattern over approximately 10 years. Length showed a decrease in A-C_C, both in the maxilla and mandible, and an increase in other measurements. This was similar to the report in 1993[3]. Taking the results for width into consideration, it would appear that little change occurs in the growth pattern of length over this 10-year period. Height showed a decrease in both measurements, which was different from in the 1993 report[3], the 70s group of the present report, and the report by Shimomura *et al.*[5]. Dental attrition of the primary molars affected the results for boys in the 2000s group. However, these changes between 4 and 5 years of age boys born in 2000s were not statistically significant.

In contrast, dental arch width in girls showed a decrease in 2 of 6 measurements in both the maxilla and the mandible, but an increase in other measurements. These results were slightly different from those of the 1993 report[3], where an increase was observed in all measurements. Thus, cross-sectional studies appear to show an increase, while longitudinal studies, such as that by Tsujino and Machida[6] appear to show stable results, perhaps due to the difference in study subjects. In the present study, dental arch length showed a decrease in A-C_C, but an increase in other measurements in the maxilla. These results were similar to those of the 1993 report[3]. However, an increase was observed in all measurements in the mandible in the present study, which was different from in the 1993 report[3], where a decrease was observed. This may have been due to a difference in the growth pattern over the 10-year period. Height showed an increase in both measurements. These results coincided with those of Shimomura *et al.*[5], which showed that primary dental arch height increased between 3 and 5 years of age in subjects with anterior crossbite, but differed from those of the 1993 report[3], which showed a decrease. We believe that the results for girls in the 2000s group were affected by vertical growth of alveolar bone due to intraosseous eruption of the incisor more than dental attrition. However, these changes from 4 to 5 years of age in girls born in the 2000s were not statistically significant.

3. Comparison of dental arch growth between 70s and 2000s groups

A comparison of change in primary dental arch width, length, and height between 4 and 5 years of age between the 70s and 2000s groups showed an increase in width in boys in both groups. Length showed a decrease in the 70s group, but an increase in the 2000s group. Height showed a significant increase in the 70s group, but a slight decrease in the 2000s group. These differences may have been due to change in the growth pattern over approximately 40 years.

Maxilla width showed an increase in the 70s and 2000s groups in girls, while mandibular width showed little changes in the 70s and increase in the 2000s groups. Length showed a decrease in the maxilla, but an increase in the mandible in the 70s group. In the 2000s group, however, it showed an increase, except for in one measurement in the maxilla. These differences may have been due to change in the growth pattern over approximately 40 years.

Taking the absolute value for the difference in each measurement at 4 and 5 years of age as indicating the amount of growth per year, the amount of growth was greater in the 2000s group (Tables 3 to 5). The models of the 4–5-year-old girls in the 1970s group were obtained from the same individual, whereas those in the 2000s group were obtained from different individuals. Therefore, it was impossible to make a statistical comparison of amount of growth between the two groups, as we would have had to base this comparison on differences in average amounts only. These results suggest that alveolar change in the primary dentition between 4 and 5 years of age may be more distinct in the present day.

Factors affecting growth pattern may include change in diet, nursing environment, and information on child-rearing, such as with regard to sleeping position. To investigate differences in alveolar growth during the primary dentition period among different age groups, 93 dental arch plaster models obtained from 4-year olds born between 1968 and 1974, 88 from 5-year olds born between 1968 and 1974 (70s group), 61 from 4-year olds born between 2007 and 2009, and 56 from 5-year olds born between 2006 and 2008 (2000s group) were measured for dental arch width, length, and height. The results showed different growth patterns in primary dental arch width, length, and height from 4 to 5 years old between the two age groups and sexes. The amount of change was larger in the 2000s than in the 70s group, suggesting that growth per year from 4 to 5 years of age has become more significant over the last 40 years.

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References

1) Arakawa A, Yonezu T, Tashiro A, Makiguchi T, Imai H, Shintani S (2015) Precision and reproducibility of the dental arch model measurement using dental 3D system. Jpn J Ped Dent 53: 114. (in Japanese)
2) Inoue N, Ito G, Kamegai T (1986) Small progress of occlusion and dental disease, A study on discrepancy, pp.53–64, Ishiyaku Publishers, Tokyo. (in Japanese)
3) Japanese Society of Pediatric Dentistry (1993) Research concerning the size of the primary tooth crown, primary dental arch and condition of primary occlusions of the Japanese. Jpn J Ped Dent 31: 375–388. (in Japanese)
4) Kaihara Y, Katayama A, Ono K, Kurose M, Toma K, Amano H, Nikawa H, Kozai K (2014) Comparative analyses of paediatric dental measurements using plaster and three-dimensional digital models. Eur J Paediatr Dent 15: 137–142.
5) Shimomura J, Tanabe Y, Taguchi Y, Shimooka S, Noda T (2005) Anterior crossbite in the primary dentition: proposal for a new analytical method in children. Odontology 93: 56–60.
6) Tsujino K, Machida Y (1998) A longitudinal study of the growth and development of the dental arch width from childhood to adolescence in Japanese. Bull Tokyo Dent Coll 39: 75–89.

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