

CONTINUING EDUCATION

Arch width changes from 6 weeks to 45 years of age

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The purpose of this study was to evaluate on a longitudinal basis, the changes in intercanine and intermolar widths over a 45-year span. The subjects in this study were from two pools of normal persons: (1) 28 male and 33 female infants evaluated longitudinally at approximately 6 weeks, 1 year, and 2 years of age (before the complete eruption of the deciduous dentition); and (2) 15 male and 15 female subjects from the Iowa facial growth study evaluated at ages 3, 5, 8, 13, 26, and 45. Arch width measurements on maxillary and mandibular dental casts were obtained independently by two investigators. Intraexaminer and interexaminer reliability were predetermined at 0.5 mm. From the findings in the current study, the following conclusions can be made: (1) Between 6 weeks and 2 years of age, i.e., before the complete eruption of the deciduous dentition, there were significant increases in the maxillary and mandibular anterior and posterior arch widths in both male and female infants. (2) Intercanine and intermolar widths significantly increased between 3 and 13 years of age in both the maxillary and mandibular arches. After the complete eruption of the permanent dentition, there was a slight decrease in the dental arch widths, more in the intercanine than in the intermolar widths. (3) Mandibular intercanine width, on the average, was established by 8 years of age, i.e., after the eruption of the four incisors. After the eruption of the permanent dentition, the clinician should either expect no changes or a slight decrease in arch widths. In conclusion, although the dental arch widths undergo changes from birth until midadulthood, the magnitude as well as the direction of these changes do not provide a scientific basis for expanding the arches, in the average patient, beyond its established dimensions at the time of the complete eruption of the canines and molars. Both patients and clinicians should be aware of these limitations. (Am J Orthod Dentofac Orthop 1997;111:401-9.)

The changes in the dental arch dimensions that occur as a result of growth¹⁻⁶ and treatment⁷⁻¹¹ have been of interest to the orthodontist and are carefully considered during treatment planning. Because the stability of the treatment results is of paramount importance to both the patient and the clinician, a greater understanding of these changes could influence the patient's expectations from treatment as well as the formulation of the treatment and retention plans by the clinician.

Normal Changes

Sillman⁵ evaluated a mixed longitudinal sample from birth to 25 years of age and observed that from birth to 2 years there was an increase in "intercanine" width of 5.0 mm in the maxilla and 3.5 mm in

the mandible. After 2 years of age, the intercanine width continued to increase in the maxilla until 13 years of age and in the mandible until 12 years of age, after this time canine width remained stable. Male subjects, in general, had larger arch widths than female subjects.

Knott³ in a longitudinal study quantified changes in intercanine widths between the deciduous (\bar{x} age = 5.4 years), mixed (\bar{x} age = 9.4 years), early permanent (\bar{x} age = 13.6 years), and early adulthood (\bar{x} age = 25.9 years), in both male and female subjects. In the mandibular arch the mean changes between the four stages were 2.9, 0.3, and -0.1 mm. The corresponding mean changes in the maxillary arch were 2.8, 2.0 and 0 mm. In 97% of the subjects, intercanine width in both arches either remained unchanged, increased, or decreased by 1.0 mm from the mixed to the permanent dentitions. Knott observed considerable individual variation when evaluating the total amount of intercanine changes. As an example, the average change in mandibular intercanine width between the deciduous and permanent dentitions was 3.2 mm but ranged between 0 and 6.0 mm.

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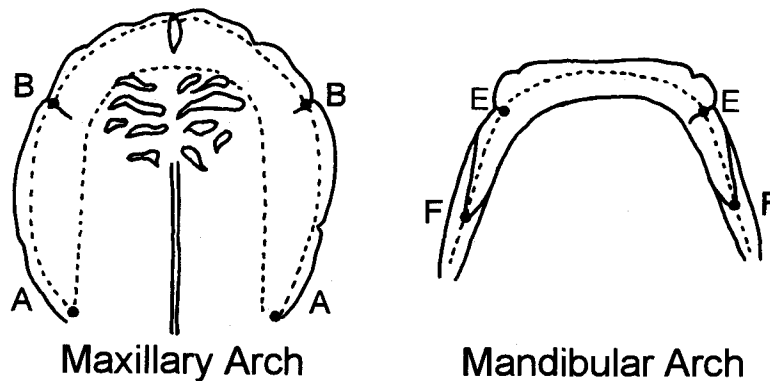


Fig. 1. Maxillary and mandibular landmarks in preeruption stages.

According to Moorrees et al.⁴ arch width does not change “materially” during the deciduous dentition from 4 to 6 years of age but increases markedly (3.0 mm) during the emergence of the maxillary and mandibular incisors and then stabilizes.

When evaluating the changes in the maxillary and the mandibular arch widths, Moyers et al.⁶ found that the difference between the intercanine widths in the two arches increased from 4.0 mm at age 4 years to 7.5 mm at age 17 years. They also observed greater sexual dimorphism in the maxillary intercanine width than in the mandibular intercanine width in the permanent dentition.

Treatment Changes

Uhde et al.⁹ evaluated the dental arch changes in patients with Class I and II malocclusions who were treated either with or without the extraction of four premolars. These patients were observed anywhere between 12 and 35 years after the completion of orthodontic treatment. Uhde et al. observed that the mean intercanine widths increased in both arches during treatment in all types of malocclusion and decreased after treatment toward its original width. Mandibular intercanine width was found to decrease close to or past the original dimension.

However, Walter^{10,11} maintained that over an average postretention time of 2 years, 62% of the extraction cases evaluated sustained an average increase of 1.4 mm in the mandibular intercanine width. Similarly, 60% of the nonextraction cases sustained an overall increase of 2.0 mm in the mandibular intercanine width. Herberger⁷ reported that 4 to 6 years after retention 68% of the nonextraction cases maintained some intercanine width

expansion. Little et al.⁸ found that, in a few cases, a net increase in mandibular intercanine width still persisted more than 10 years after retention.

The literature suggests that orthodontists are interested in evaluating the changes that occur in the arch widths with and without treatment. There is still some controversy regarding the magnitude and the timing of these changes as well as their effects on treatment planning and the subsequent stability of the treatment results. Consequently, a better understanding of the normal changes that occur in arch widths over a prolonged period may help elucidate this important clinical problem. Therefore the purpose of this study was to evaluate, on a longitudinal basis, the changes in intercanine and intermolar widths over a 45-year span between 6 weeks and 45 years of age.

MATERIALS AND METHODS

The subjects in this study were from two pools of normal persons: (1) 28 female and 33 male infants evaluated at various intervals including: 6 weeks, 1 year, and 2 years of age, before the complete eruption of the deciduous dentition; and (2) 15 male and 15 female subjects from the Iowa growth study, evaluated at various ages including 3, 5, 8, 13, 26, and 45 years.

The data for the two groups are presented separately and within each group the data are longitudinal.

The 6 Weeks to 2 Years Sample

The infants were selected from the Obstetric and Pediatric Departments at the University of Iowa Hospitals and Clinics and from private pediatric practices in Iowa City, Iowa. The only criteria for selecting the infants for the study were (a) that they were healthy full-term babies with no apparent congenital anomalies, and (b) the availability of the family for evaluation over an 8-year period.

Table 1. Descriptive statistics and results of analysis of variance comparing changes in maxillary and mandibular intercanine arch widths (mm) between successive ages from 6 weeks and 45 years of age

	Male			Female		
	\bar{x}	SD	<i>p</i>	\bar{x}	SD	<i>p</i>
<i>Maxillary intercanine width</i>						
Preeruption						
6 weeks	26.3	1.9		25.3	1.4	
1 year	28.6	1.7	0.0001	27.3	1.7	0.0001
2 years	30.5	1.3	0.0001	29.3	1.4	0.0001
Posteruption						
3 years	28.8	2.5	0.0079	27.4	1.8	0.0197
5 years	30.3	2.6	0.0001	28.4	1.7	0.0001
8 years	32.5	3.2	0.0001	30.7	2.0	0.0001
13 years	35.1	2.7	0.1900	33.1	1.6	0.1780
26 years	34.0	2.3	0.1180	32.3	1.8	0.0190
45 years	33.7	2.3		31.9	2.0	
<i>Mandibular intercanine width</i>						
Preeruption						
6 weeks	22.5	1.9	0.0001	21.7	1.4	0.0001
1 year	24.6	1.1	0.5100	23.4	1.3	1.0000
2 years	24.8	1.2		23.9	1.3	
Posteruption						
3 years	22.1	1.7	0.0010	21.5	1.3	0.0115
5 years	23.4	1.8	0.0001	22.3	1.3	0.0001
8 years	25.5	2.1	0.4000	24.4	1.4	0.0165
13 years	25.7	1.6	0.3130	25.4	1.8	0.0674
26 years	25.2	1.8	0.0029	24.4	1.4	0.0002
45 years	24.8	1.7		23.8	1.4	

\bar{x} = Mean; SD = standard deviation; *p* = probability.

Timing of visits. The infants were examined at various intervals but for this study, dental casts available at the initial visit, i.e., within 6 weeks after birth, at 12 months, and at 24 months, before the deciduous dentition had completely erupted, were evaluated.

Of 135 babies originally examined, 33 boys and 28 girls had maxillary and mandibular dental casts at the three observation times.

Preeruption landmarks. Five maxillary and seven mandibular landmarks were identified on each set of study casts (Fig. 1). The landmarks used in this study were defined according to Sillman⁵ as follows:

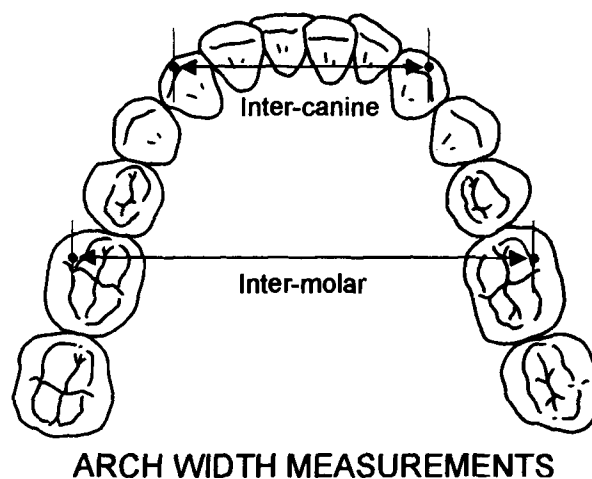


Fig. 2. Measurements of arch widths in posteruption stages.

Maxillary:

1. Lateral sulcus point: The point at which the lateral sulcus crosses the crest of the alveolar ridge.
2. Postgingival point: The point on the posterior border of the gum pad at the crest of the alveolar ridge.

Mandibular:

3. Lateral sulcus point: The point at which the lateral sulcus crosses the crest of the ridge
4. Posterior border of the pad: The point on the posterior margin of the pad where it drops to the posterior ridge.

All landmarks were marked by one investigator and verified by another.

Dental arch measurements (Fig. 1). The following measurements were obtained on each set of study models at each stage:

- Maxillary anterior arch width (B-B)
- Maxillary posterior arch width (A-A)
- Mandibular anterior arch width (E-E)
- Mandibular posterior arch width (F-F)

The 3 to 45 Years Old Sample

The Iowa Facial Growth Study was started in March 1946, by V. Meredith and L. Higley. Eighty-nine boys and 86 girls "not younger than 3 years" were originally enrolled. All records were taken semiannually until age 12 years, annually during adolescence, and once during early adulthood.^{2,3} Twenty years later, in midadulthood, 16 female and 15 male subjects who were located in different parts of the country consented to report for a follow-up examination.²

The subjects were predominantly of northern European descent, and, at the time, were living in or near Iowa City, Iowa. Most were from families of "above average

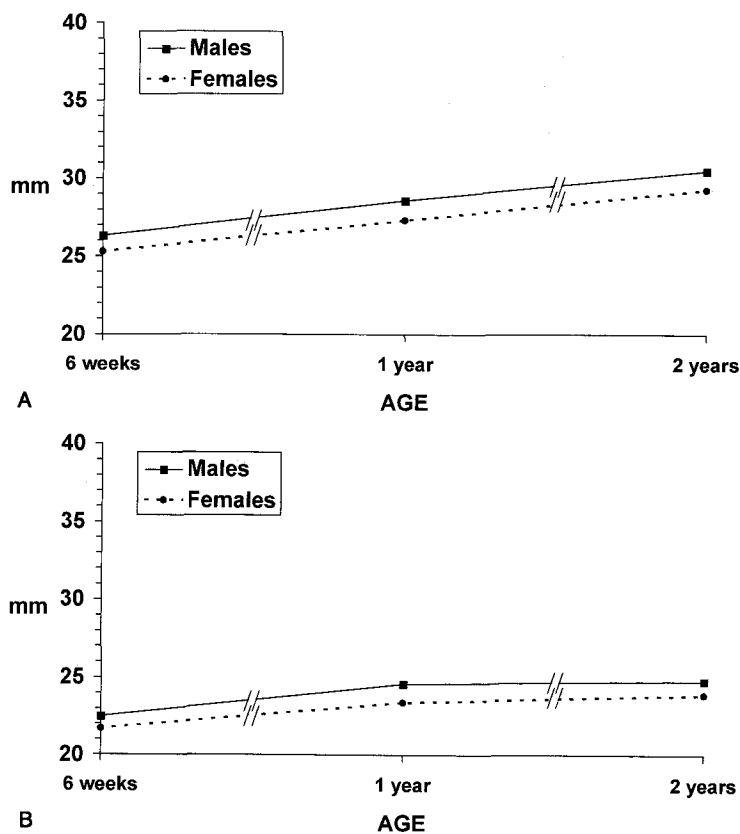


Fig. 3. A, Changes in maxillary anterior arch width ages 6 weeks to 2 years. **B,** Changes in mandibular anterior arch width ages 6 weeks to 2 years.

socioeconomic status.³ All had clinically acceptable facial skeletal features and occlusion—that is, a Class I molar and canine relationship, anterior crowding of less than 2 mm at the time of eruption of the second permanent molars, and no apparent facial disharmony. None of these subjects had congenitally missing teeth and none had undergone orthodontic therapy. In addition, each subject had a complete set of records at 3, 5, 8, 13, 25, and 45 years of age.

Of the original 175 children enrolled in the study, only 16 female and 15 male subjects had complete records at both young adulthood (25 years) and midadulthood (45 years). One female subject had orthodontic treatment during that period and was excluded from this study. The previously mentioned selection criteria limited the number of subjects in this investigation.

The time span between the young and the midadulthood observations for the female subjects ranged from 18.2 to 20.7 years, with an average span of 19.9 ± 0.7 years. Whereas, the time span between young and midadulthood in the male subjects ranged from 18.25 to 22.2 years, with an average span of 20.3 ± 1.2 years.

Arch width measurements (Fig. 2). These included maximum rectilinear distances between the cusp tips of the canines, the mesial cusp tips of the second deciduous molars at age 3 years and 5 years, and the mesiobuccal cusp tips of the first permanent molars, after their eruption, at all the subsequent ages.^{3,5}

Measurements Reliability

Double measurements were obtained for each parameter with a dial caliper accurate to 0.05 mm. Intraexaminer reliability was predetermined at 0.25 mm. A second examiner randomly checked 10% of the measurements obtained. Allowable interexaminer reliability also was predetermined at 0.25 mm. Three percent of the checked measurements were above this limit, none more than 0.5 mm. For the purpose of this study, it was concluded that this level of accuracy was appropriate.

Statistical Analysis

Descriptive statistics on the changes in arch width parameters were calculated specifically at 6 weeks, 12

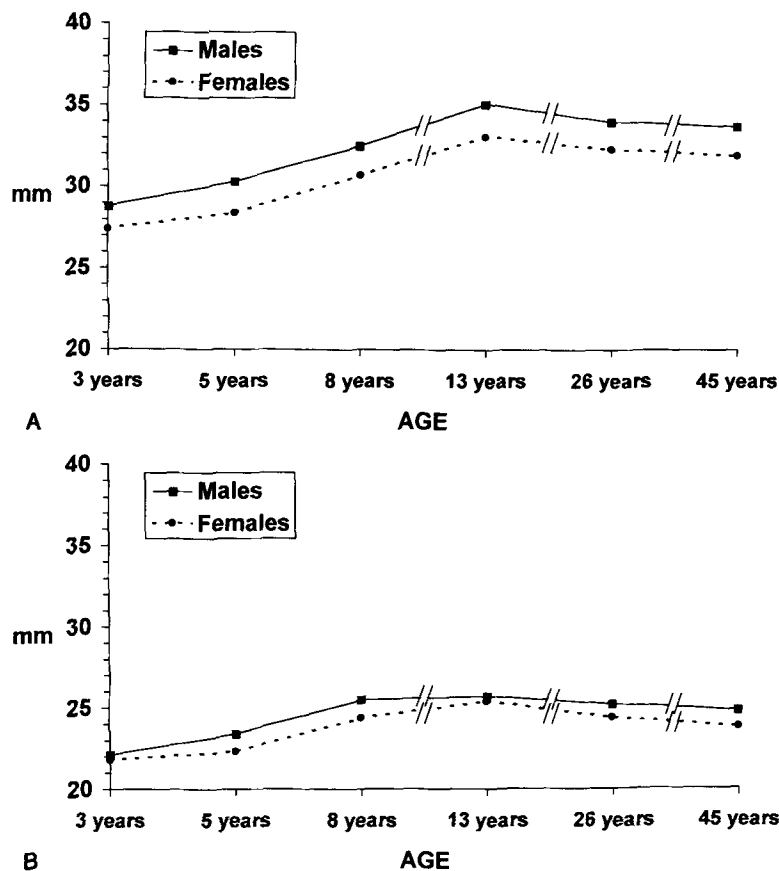


Fig. 4. **A**, Changes in maxillary intercanine width ages 3 to 45 years. **B**, Changes in mandibular intercanine width ages 3 to 45 years.

months, and 24 months, also at 3, 5, 8, 13, 26, and 45 years of age.

The changes over time were calculated with the repeated measures analysis of variance. Significance was predetermined at the 0.05 level of confidence.

FINDINGS

Male Versus Female Differences

Longitudinal comparisons of the changes in the absolute values between male and female subjects indicated that male subjects were significantly larger than female subjects in both maxillary and mandibular arch widths.

Changes in Intercanine Widths (Table 1, Figs. 3 and 4)

Preruptive stages: There was a significant increase ($p = 0.0001$) in maxillary intercanine width between 6 weeks to 1 year and 1 to 2 years, in both boys and girls. Mandibular intercanine widths in

both sexes, increased significantly ($p = 0.0001$) between 6 weeks and 1 year but not between 1 and 2 years of age ($p = 0.5$).

Posteruptive stages: There was a significant increase in maxillary intercanine widths between 3 to 5, 5 to 8, and 8 to 13 years ($p < 0.01$) in both boys and girls. Between 13 to 26 years and 26 to 45 years, there was a small decrease in the mean intercanine width in both sexes, but the decrease was statistically significant ($p = 0.019$) only between 26 to 45 years, in female subjects.

There was an increase in mandibular intercanine width until age 13 years but the increase was significant ($p < 0.01$) until age 8 years in boys and 13 years in girls. After 13 years of age, intercanine widths decreased slightly at 25 and 45 years of age. The decrease was significant between 26 and 45 years of age ($p = 0.0002$) in both male and female subjects.

Table II. Descriptive statistics and results of analysis of variance comparing changes in maxillary and mandibular intermolar arch widths (mm) between successive ages from 6 weeks and 45 years of age

	Male			Female		
	\bar{x}	SD	<i>p</i>	\bar{x}	SD	<i>p</i>
<i>Maxillary intermolar width</i>						
<i>Preeruption</i>						
6 weeks	27.4	2.3		26.9	2.1	
1 year	30.1	2.0	0.0001	29.1	2.3	0.0001
2 years	32.7	2.7	0.0001	30.8	2.6	0.0066
<i>Posteruption</i>						
3 years*	40.9	2.3	0.0001	39.3	2.2	0.0063
5 years*	43.5	3.2	0.0001	40.8	1.9	0.0001
8 years†	51.0	3.0	0.0001	48.1	2.2	0.0001
13 years†	53.4	2.9	0.8840	50.1	2.6	0.0250
26 years†	53.6	2.9	0.4930	48.3	1.6	0.4090
45 years†	53.4	2.7		48.4	1.6	
<i>Mandibular intermolar width</i>						
<i>Preeruption</i>						
6 weeks	30.0	1.9	0.0001	28.8	1.6	0.0001
1 year	32.5	1.6	0.8269	30.7	1.6	0.1949
2 years	32.6	1.8		31.2	1.5	
<i>Posteruption</i>						
3 years*	34.8	2.0	0.0001	34.8	6.2	0.6900
5 years*	36.9	2.3	0.0001	34.4	1.9	0.0001
8 years†	44.6	2.7	0.0001	42.1	2.0	0.0098
13 years†	45.9	2.6	0.9910	43.0	2.4	0.7960
26 years†	46.0	3.0	0.4025	41.5	2.3	0.7004
45 years†	45.7	3.2		41.5	2.6	

\bar{x} = Mean; SD = standard deviation; *p* = probability.

*Arch width of the second deciduous molars.

†Arch width of the first permanent molars.

Changes in Intermolar Width (Table II, Figs. 5 and 6)

Preeruption stage: There was a significant ($p < 0.001$) increase in maxillary intermolar width in both boys and girls between 6 weeks and 1 year, as well as between 1 and 2 years of age. There was a significant ($p = 0.0001$) increase in mandibular intermolar width between 6 weeks and 1 year, but not between 1 and 2 years of age.

Posteruption stage: In male subjects, there was a significant ($p = 0.0010$) increase in maxillary and mandibular intermolar widths between 3 to 5, 5 to 8, and 8 to 13 years. There were no significant changes

in intermolar width between 13 to 26 and 26 to 45 years.

In female subjects, there was a similar significant increase up to 13 years of age in both maxillary and mandibular intermolar widths. Between 13 to 26 and 26 to 45 years, there was a slight decrease in both maxillary and mandibular widths but the decrease was statistically significant ($p = 0.0250$) only between 13 and 26 years of age, in maxillary width.

DISCUSSION

Changes in the preeruption stage: As expected, there was a significant increase in the anterior and posterior arch widths with age, in both male and female subjects. Of particular interest was the fact that the mean intercanine width increase, in the first 2 years of life, was either equal to or only 1.0 mm less than the total change between 3 and 45 years of age. Similarly, the total amount of change in the intermolar width after the eruption of the first permanent molars in male and female subjects was less than 1.0 mm, except for maxillary intermolar width in male subjects, which increased by 2.4 mm (Table II).

Changes in the posteruption stage: Maxillary intercanine width increased between 3 and 13 years of age in both male ($\bar{x} = 6.3$ mm) and female subjects ($\bar{x} = 5.7$ mm). After that age, it decreased and continued to do so until age 45 years in both male ($\bar{x} = -1.4$ mm) and female subjects ($\bar{x} = -1.2$ mm).

Mandibular intercanine width also increased between 3 and 13 years of age in both male ($\bar{x} = 3.6$ mm) and female subjects ($\bar{x} = 3.9$ mm). Between 13 and 45 years of age, the width decreased in male ($\bar{x} = -0.9$ mm) and female subjects ($\bar{x} = -1.6$ mm).

The findings from the current study indicated that, for all practical clinical purposes, the arch width dimensions were established in the mixed dentition (8 years of age) with some, but minimal, increase until the early permanent dentition (13 years) and progressive but minimal decrease in early and midadulthood. Because most orthodontic treatment, whether it is in one or two phases, occur between 8 and 13 years, it is important for the clinician to take into consideration the minimal overall changes that occur in the mandibular anterior dental arch width, with time.

Burdi and Moyers¹² pointed to three important facts when studying dental arch changes: (1) width dimensional increases almost totally involve alveolar process growth with little skeletal width increase particularly in the mandibular arch; and (2) the

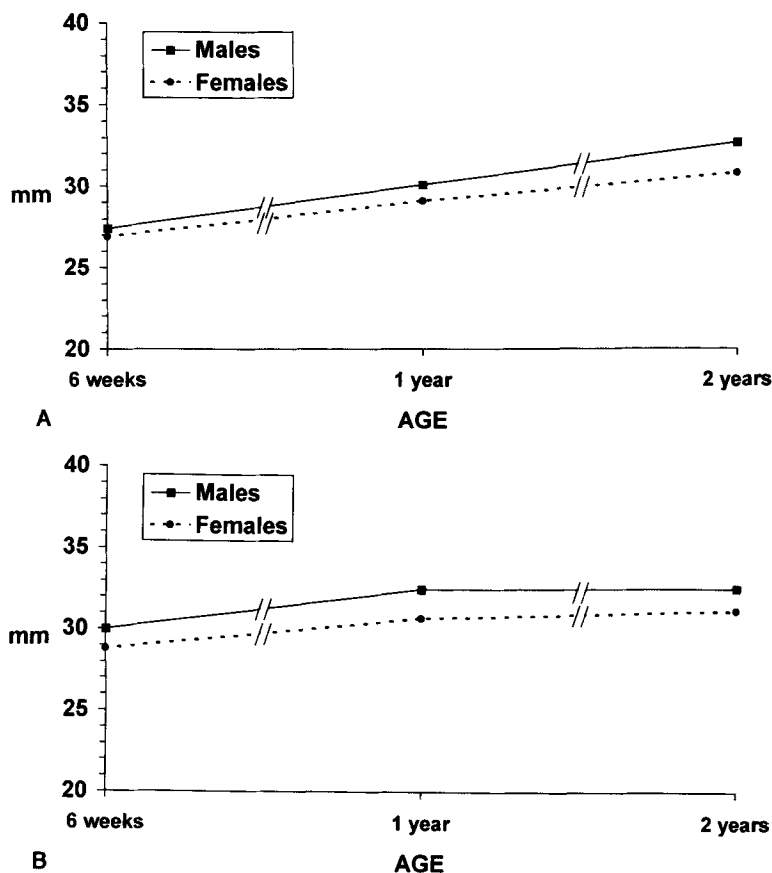


Fig. 5. **A**, Changes in maxillary posterior arch width ages 6 weeks to 2 years. **B**, Changes in mandibular posterior arch width ages 6 weeks to 2 years.

direction of the vertical alveolar growth differs significantly in the maxillary and mandibular arches. Specifically, maxillary alveolar processes diverge as the teeth erupt, whereas the growth of the mandibular alveolar process is more parallel. Such changes have significant clinical implications because they may allow for a greater differential increase in the maxillary arch width during treatment.

In general, the later decrease in arch widths with age were more noticeable in the mandibular than in the maxillary arch. These differences in the changes between the two dental arches might explain why some investigators^{6,10,12} observed that the net increase in intercanine width with treatment was more stable in the maxillary arch.

The current findings further reinforce the postulate presented by Herberger⁷ and Little et al.⁸ that, in general, the pretreatment intercanine width dimensions should not be violated and that the mandibular intercanine width should be used as a guide around which to build the eventual arch form. This

is further substantiated by the fact that in the current investigation, in more than 95% of the subjects, the changes in intercanine and intermolar widths between 25 and 45 years of age ranged between 0 and ± 1.0 mm in both male and female subjects. Similar limited changes in arch widths occur between 13 and 25 years of age.

The current findings also support the general concepts forwarded by Knott,³ Moorrees,⁴ Sillman,⁵ and Moyers⁶ regarding the normal changes in arch widths dimensions. In addition, the current findings extend our understanding of the changes that occur in the period between early to midadulthood.

CONCLUSIONS

From the findings in this study, the following conclusions can be made:

1. Between 6 weeks and 2 years of age, i.e., before the complete eruption of the deciduous dentition,

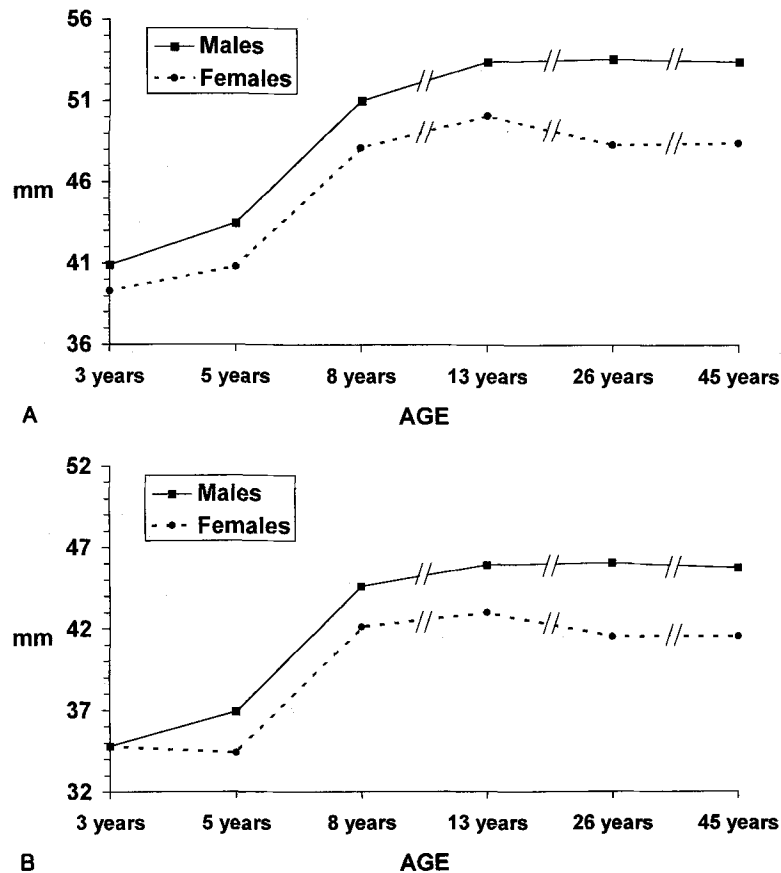


Fig. 6. A, Changes in maxillary intermolar width ages 3 to 45 years. At 3 and 5 years, second deciduous molar were measured, while at 8, 13, 26, and 45 years, first permanent molars were measured. **B,** Changes in mandibular intermolar width ages 3 to 45 years. At 3 and 5 years, second deciduous molar were measured, while at 8, 13, 26, and 45 years first permanent molars were measured.

there were significant increases in the maxillary and mandibular anterior and posterior arch widths in both boys and girls.

- Intercanine and intermolar widths significantly increased between 3 and 13 years of age in both the maxillary and mandibular arches. After the complete eruption of the permanent dentition, there was a slight decrease in the dental arch widths, more in the intercanine than in the intermolar widths.
- Mandibular intercanine width, on the average, was established by 8 years of age, i.e., after the eruption of the four incisors. After the eruption of the permanent dentition, the clinician should either expect no changes or a minimal decrease in arch widths.

In conclusion, although the dental arch widths undergo changes from birth until midadulthood, the magnitude as well as the direction of these changes do not

provide a scientific basis for expanding the arches in the average patient beyond its established dimension at the time of complete eruption of the canines and molars. Both patients and clinicians should be aware of these limitations.

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