

Arch length changes from 6 weeks to 45 years

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Changes in the dental arch dimensions that occur as a result of growth and treatment are of interest to the orthodontist and must be carefully considered when planning treatment. The term *growth* may refer to a change in size as well as an increase in either the size or number of organizational units. Meredith¹ defined growth as "the entire series of anatomic and physiologic changes taking place between the beginning of prenatal life and the close of senility." Early growth, that of childhood and adolescence, is dramatic and well documented;²⁻⁷ however, changes that occur during adulthood are much less obvious and have been the object of fewer studies.

Because of the increasing number of adults seeking orthodontic care, an understanding of the changes that normally take place in the cran-

iofacial structures during later stages of development becomes critical. Since the stability of treatment results is of paramount importance to both patients and clinicians, a greater understanding of these changes could influence the patient's expectations as well as the treatment and retention plans designed by the clinician.

Lundström⁷ evaluated 41 pairs of twins, including both males and females, from an initial age of 9 to 19 years (mostly 12 to 15 years) to a final age of 23 to 32 years (mostly 26 to 30 years). He measured the changes in arch depth and width in an attempt to establish the cause of increased crowding. Arch width, measured at the first premolars and permanent first molars, changed little. On the other hand, mean arch depth decreased by 1.3 mm in the maxilla and 1.6 mm in the mandible.

Abstract

The purpose of this study was to evaluate, on a longitudinal basis, changes in maxillary and mandibular arch length over a 45-year period. Subjects were drawn from two pools of normal individuals. Twenty-eight male and 33 female infants were evaluated longitudinally at 6 weeks, 1 year, and 2 years (before the eruption of the deciduous dentition). Fifteen males and 15 females from the Iowa Facial Growth Study were evaluated at 3, 5, 8, 13, 26, and 45 years. Arch length measurements were obtained independently by two investigators. Intra- and interexaminer reliabilities were predetermined at 0.25 and 0.5 mm, respectively. The greatest incremental increases occurred during the first two years of life. Arch length continued to increase until 13 years in the maxillary arch, and until 8 in the mandibular. Then significant and consistent decreases occurred in both arches mesial to the permanent first molars.

Key Words

Arch length • Longitudinal • Normal

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Figure 1
Landmarks used to measure arch length in the pre-eruptive stage.

Figure 2
Landmarks and measurements of arch length in the posteruptive stage.

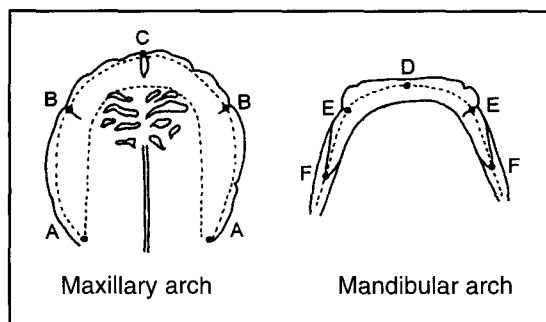


Figure 1

Using a mixed longitudinal sample, Sillman⁸ evaluated changes in various dental arch dimensions from birth to early adulthood. He observed that in both jaws the greatest incremental increase in arch length occurred between birth and 2 years. (Sillman's definition of arch length is equivalent to arch depth, not circumference.) He suggested that some increase might occur during eruption of the permanent incisors, but that anterior arch length is essentially established by 3 years, i.e., after eruption of the deciduous dentition. Between 3 years and early adulthood (19 years or later) there were, Sillman observed, 1.5 mm and 2.0 mm mean decreases, respectively, in maxillary and mandibular lengths.

Bishara et al.³ evaluated cephalometric and dental arch changes in adolescent subjects between 13 and 25 years. They observed increases in tooth size-arch length discrepancy with age in both arches, resulting from decreases in arch length during those years.

The literature review suggests that orthodontists are interested in evaluating changes that occur in arch dimensions with and without treatment. Some controversy exists regarding the magnitude and timing of these changes as well as their effects on treatment and the subsequent stability of the result. Consequently, a better understanding of the normal changes that occur in arch length over a prolonged period may help to elucidate this important clinical problem. Therefore, the purpose of this study was to evaluate, on a longitudinal basis, the changes in maxillary and mandibular total arch length (circumference) over a 45-year span between 6 weeks and 45 years.

Materials and methods

The subjects in this study were from two pools of normal individuals: (1) 28 female and 33 male infants evaluated at various intervals before the complete eruption of the deciduous dentition, including 6 weeks, 1 year, and 2 years; and (2) 15 males and 15 females from the Iowa growth

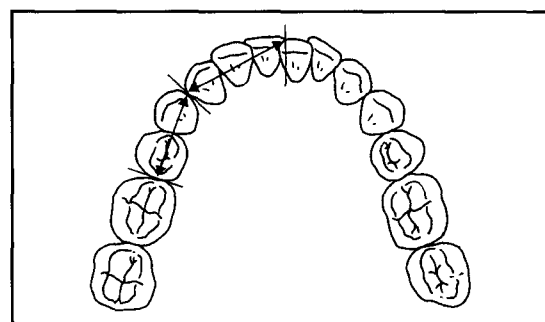


Figure 2

study, evaluated at various ages, including 3, 5, 8, 13, 26, and 45 years.

The 6 weeks-to-2 years sample

Infants were recruited 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 selection were: (a) healthy full-term babies with no apparent congenital anomalies, and (b) availability of the family for evaluation over an 8-year period.

Infants were examined at various intervals; for the present study, dental casts were made at the initial visit, i.e., within 6 weeks after birth, at 12 months, and at 24 months, i.e., before the primary dentition had completely erupted.

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

Five maxillary and 7 mandibular landmarks were identified on each set of study casts (Figure 1). The landmarks used in the present study were defined according to Sillman⁵ as follows:

Maxillary

Postgingival point: point on the posterior border of the gum pad at the crest of the alveolar ridge.

Lateral sulcus point: the point at which the lateral sulcus crosses the crest of the alveolar ridge.

Incisive point: anteriormost point on the incisive papilla in line with the crest of the alveolar ridge.

Mandibular

Incisive point: midline on the crest of the alveolar ridge.

Lateral sulcus point: point at which the lateral sulcus crosses the crest of the ridge.

Posterior border of the pad: 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

The following dental arch measurements were obtained on each set of study models at each stage (Figure 1).

Maxillary anterior and posterior arch lengths: sum of the right and left A-B and C-B measurements.

Mandibular anterior and posterior arch length: sum of the right and left F-E and E-D measurements.

The 3 years-to-45 years sample

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

The subjects were predominantly of northern European descent, and, at the beginning of the study, were living in or near Iowa City, Iowa. Most were from families of "above average socioeconomic status."^{3,4} All had clinically acceptable facial skeletal features and occlusion—that is, Class I molar and canine relationship, anterior crowding of less than 2 mm at the time of eruption of the permanent second molars, and no apparent facial disharmony. None of these subjects had congenitally missing teeth and none had undergone orthodontic therapy.

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

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

Arch length (circumference) measurements included the sum of the right and left anterior and posterior segmental arch lengths for the maxillary and mandibular arches (Figure 2).

Double measurements were obtained for each parameter using a dial caliper accurate to 0.05 mm. Intra-examiner reliability was predetermined at 0.25 mm. A second examiner randomly checked 10% of the measurements obtained. Allowable interexaminer reliability also was pre-

Table 1
Descriptive statistics and results of analysis of variance*
evaluating changes in maxillary and mandibular total arch lengths
(in mm) from 6 weeks to 45 years of age

	Males		Females	
	\bar{x}	S.D.	\bar{x}	S.D.
Maxillary arch length				
Pre-eruption				
6 weeks	68.4	5.2	66.4	4.6
1 year	78.5	3.3	76.1	3.5
2 years	83.5	3.4	82.8	4.2
Posteruption				
3 years	73.9	3.2	72.3	3.0
5 years	74.6	4.2	72.9	2.9
8 years	76.9	4.8	74.0	3.5
13 years	77.9	4.1	74.7	3.2
26 years	73.2	4.4	71.1	2.7
45 years	72.2	4.5	70.1	3.1
Mandibular arch length				
Preeruption				
6 weeks	60.6	3.8	59.2	3.4
1 year	71.6	4.1	69.0	4.3
2 years	74.8	3.3	73.2	3.1
Posteruption				
3 years	67.2	3.2	64.9	2.8
5 years	68.3	2.9	65.7	3.2
8 years	69.1	3.2	66.9	2.1
13 years	66.7	3.9	63.7	3.3
26 years	62.3	4.2	59.5	3.3
45 years	61.7	4.3	58.6	5.2

\bar{x} = Mean; S.D. = Standard Deviation; p = probability

*All statistical comparisons of the changes between any two successive stages were significant at $p \leq 0.05$, whether the change was an increase or a decrease in arch length.

determined 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.

Descriptive statistics on the changes in arch length measurements were calculated specifically at 6 weeks, 12 months, and 24 months, also at 3, 5, 8, 13, 26, and 45 years of age.

Changes over time were calculated using the repeated measures analysis of variance.^{9,10} Significance was predetermined at the 0.05 level of confidence.

Results

Male vs. female differences

Longitudinal comparisons of the changes in the absolute values between males and females indicated that males have significantly ($p \leq 0.05$) greater total arch length in both arches than females.

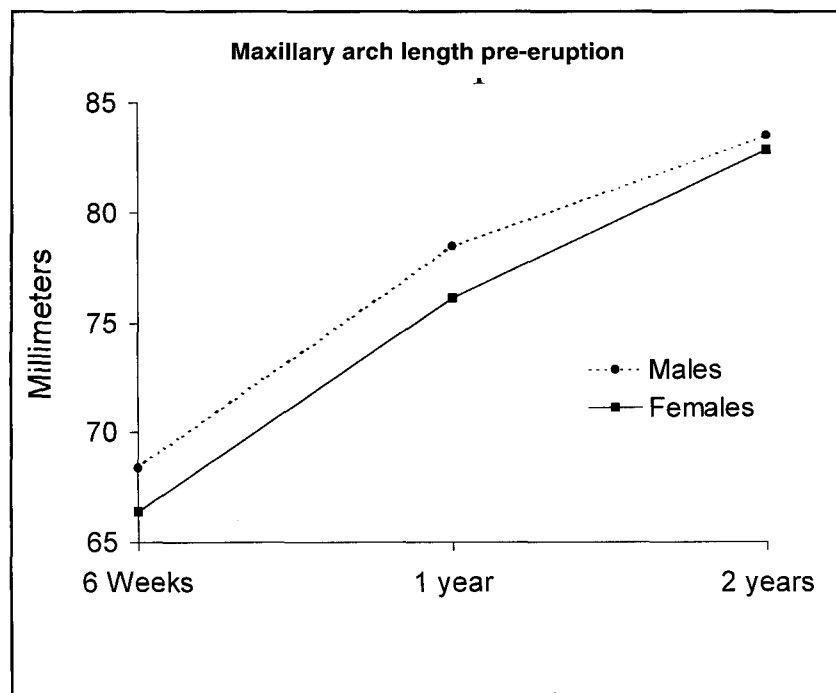


Figure 3A

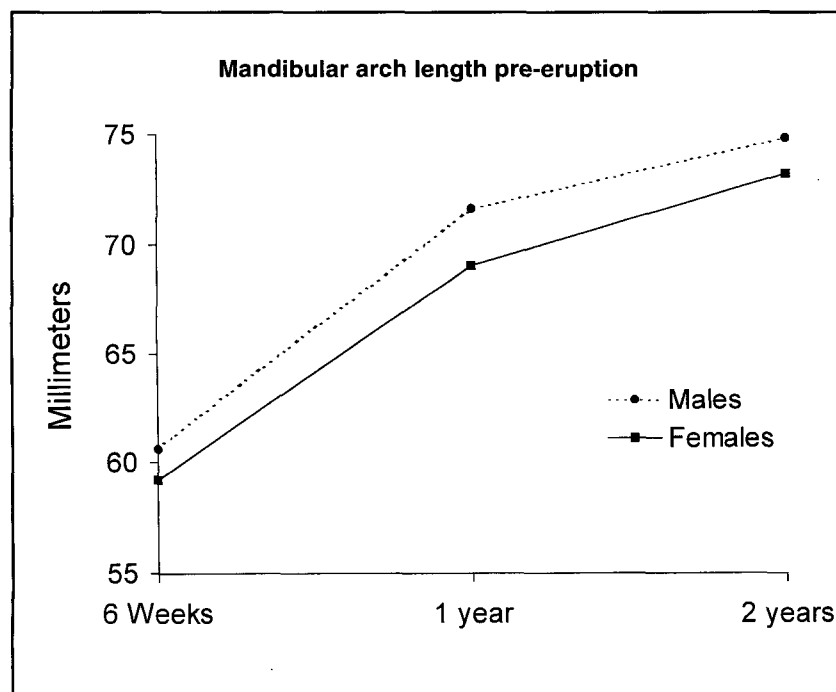


Figure 3B

Figure 3A-B
Changes in maxillary (A) and mandibular (B) arch lengths between 6 weeks and 2 years of age in males and females

Changes in total arch length (Table 1)

From 6 weeks to 2 years maxillary arch length increased significantly ($p \leq 0.05$), averaging 15.1 mm in males and 16.4 mm in females. In the mandibular arch, the corresponding increases were 14.2 and 14.0 mm. (Figure 3A-B)

From 3 to 13 years, maxillary arch length increased significantly ($p \leq 0.05$), by 4.0 mm in males and 2.4 mm in females. On the other hand, the increase in mandibular arch length was complete by 8 years. The average increase between 3 and 8 years was 1.9 mm in males and 2.0 mm in females. Between 8 and 13 years, mandibular arch length started to decrease significantly ($p \leq 0.05$), by 2.4 mm in males and 3.2 mm in females. (Figure 4A-B)

Between 13 and 45 years, maxillary arch length decreased significantly ($p \leq 0.05$) in both males ($\bar{x} = 5.7$ mm) and females ($\bar{x} = 4.6$ mm). Similarly, mandibular arch length decreased between 8 and 45 years, by an average of 7.4 mm in males and 8.3 mm in females.

Discussion

The changes in arch length that occur through the life span of each individual are important to the clinician involved in the treatment of malocclusion. Understanding the changes will not only help the clinician design an appropriate treatment plan, but will also help the clinician explain to the patient the changes that may occur during treatment as well as after retention is discontinued.

The present findings indicate that the greatest incremental increases in both maxillary and mandibular total arch length occurred during the first two years of life. Maxillary and mandibular arch lengths expressed increases at 13 years and 8 years, respectively. These changes are probably related to the eruption of the permanent incisors.

Following these ages, there were significant and consistent decreases in arch lengths mesial to the permanent first molars in both the maxillary and mandibular arches. These decreases continued until age 45. Normally, the teeth do not change significantly in crown size except through inter-

proximal attrition. As a result, the decrease in arch length is translated as an increase in the tooth size-arch length discrepancy, unless interproximal attrition keeps pace with the decrease in arch lengths. As stated earlier, between 13 and 45 years, maxillary arch length decreased an average of 5.7 mm in males and 4.6 mm in females and mandibular arch length decreased 5.0 mm in both sexes.

Conclusions

The present findings indicate that:

1. The greatest incremental increases in maxillary and mandibular arch length occur during the first two years of life.
2. Arch length continues to increase until 13 years in the maxillary arch and 8 years in the mandibular arch.
3. Following these ages, significant decreases in arch length occurred until 45 years of age.

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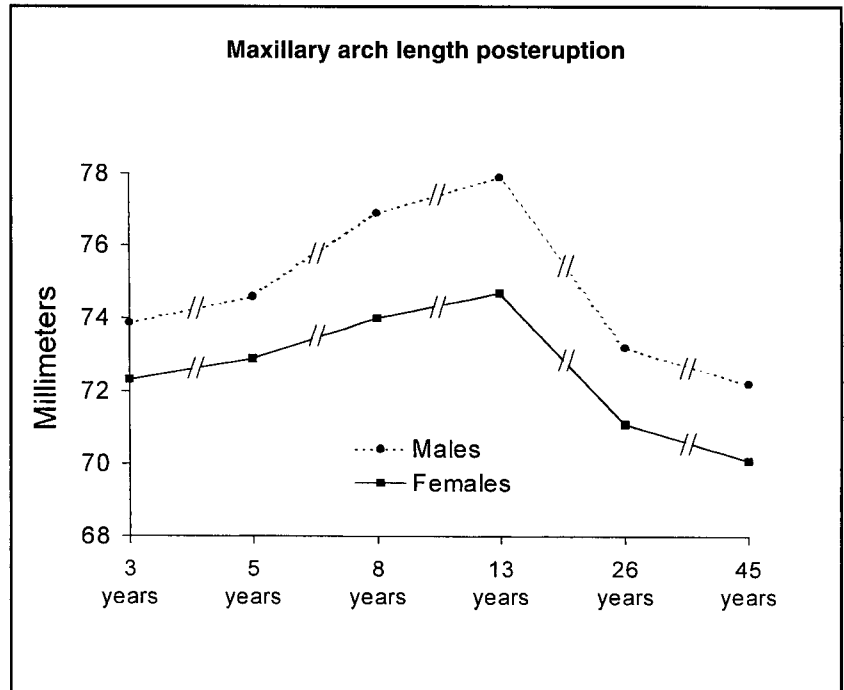


Figure 4A

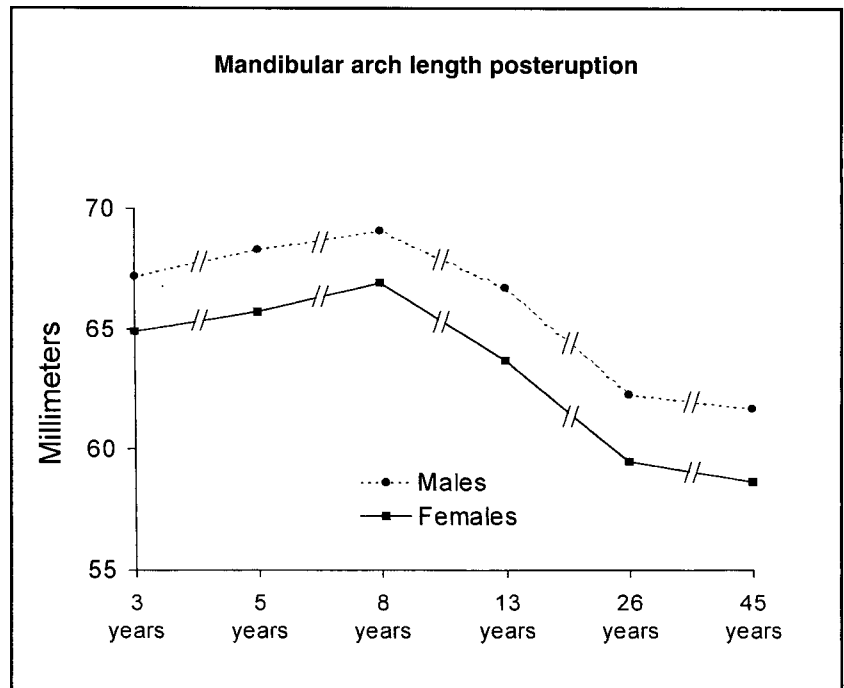


Figure 4B

Figure 4A-B

Changes in maxillary (A) and mandibular (B) arch lengths between 2 years and 45 years of age in males and females

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