

Changes in the dental arches and dentition between 25 and 45 years of age

Samir E. Bishara, BDS, MSD Ortho, MS; Jean E. Treder, DDS, MS; Paul Damon; Mark Olsen

The term "growth" may refer to a change in size or an increase in 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 later growth, that of adulthood, is much less obvious and the object of far fewer studies.

Because of the increasing number of adults seeking orthodontic care, an understanding of the changes that normally take place in the craniofacial structures at later stages of development becomes critical.

Changes in the dental arches

Lundström⁸ evaluated age-related changes in the dental arches. He followed 41 pairs of twins, 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 found that approximately half the subjects (53%) showed no change in the spacing of maxillary teeth, while the other half (47%) showed changes toward more crowded conditions. Only 16% had no change in mandibular spacing, while the majority (84%) changed toward more crowding. Lundström⁸ also measured changes in arch depth and width in an attempt to establish causes for the increased crowding. Arch width, measured at the first premolars and the permanent first molars, changed little. Arch depth, on the other hand, decreased in both arches. Maxillary arch depth decreased by 1.3 mm and mandibular arch depth decreased by 1.6 mm.

Bishara et al.³ evaluated dental arch changes in adults and observed increased crowding with age in both arches.

Abstract

The purpose of this longitudinal investigation was to study changes in the dental arches and dentition that occur in midadulthood in an untreated, normal sample. The subjects had Class I molar and canine relationships with less than 4.0 mm of overjet and less than 50% overbite. None had undergone previous orthodontic treatment. Evaluations and measurements were made from dental casts and periapical radiographic surveys of 15 females and 15 males from approximately 25 years to 46 years. The findings indicate that over the span of the study, significant changes occur in the maxillary and mandibular dental arches and dentition in both males and females, including a clinically significant increase in tooth size - arch length (circumference) discrepancy. These changes should be considered part of the normal maturational process and should be taken into consideration when planning treatment and retention options for adolescent and adult patients.

Key Words

Dental arches • Permanent • Longitudinal • Midadulthood

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Table 1
Descriptive statistics on the ages of male and female subjects
at the two stages evaluated.

Age group	Females (n=15)			Males (n=15)		
	$\bar{x}$	SD	Range	$\bar{x}$	SD	Range
Young adulthood	26.0	1.8	22.4 - 28.4	25.1	2.1	22.4 - 29.8
Midadulthood	45.9	2.0	42.2 - 48.5	45.4	2.3	42.3 - 48.2

Changes in the dentition

In a 1990 study, Burt et al.⁹ reported changes in the dental status of 167 patients from 1959 to 1987. Over the 28-year period, 28 patients became edentulous and lost an average of 18.0 teeth, while age-matched dentate people lost only 3.2 teeth on average. In another study of the same population,¹⁰ the loss of periodontal attachment was evaluated. It was found that 13.3% of the subjects had an average loss of 2.0 mm, 30% a loss of 3.0 mm, 1.2% a loss of 4.0 mm or more, and 59.3% either did not change or changed less than 1.0 mm. The authors suggested that some of the risk factors for the loss of periodontal attachment include: age, smoking, and the presence of tooth mobility.¹⁰

In a longitudinal study of 736 dentulous male Veterans Administration patients, Chauncey et al.¹¹ found an average loss of 1.6 teeth per patient. The primary causes for tooth extractions were dental caries (33.3%), preparation for prosthesis (31.3%), and periodontal disease (18.7%).

In summary, longitudinal studies are scant with respect to dental arch changes that occur between early and middle adulthood.

The purpose of this study was to investigate changes in the dental arch parameters and dentition between 25 and 45 years of age in males and females.

Materials and methods

Subjects

The Iowa Facial Growth Study was started in March 1946 by Drs. V. Meredith and L. Higley. The original enrollment included 89 boys and 86 girls, "not younger than 3 years." Records were taken semi-annually until age 12 years, annually during adolescence, and once during early adulthood.¹² Twenty years later, in midadulthood, 15 females and 15 males were located in different parts of the country, and they consented to follow-up examinations.

The time span between the original early adulthood observations and the follow up observations ranged from 18.3 to 20.7 years with an

average span of 19.9 ± 0.7 years ($\pm$ refers to the standard deviation) for females, and from 18.3 to 22.2 years with an average span of 20.3 ± 1.2 years for males. The ages of male and female subjects studied are presented in Table 1.

Dental cast analysis

All impressions were taken using alginate material and were poured in yellow stone. Dental casts and full mouth radiographic surveys were inspected for missing teeth and restorations. None of the subjects had more than two or three missing teeth, thus the vertical dimension was not influenced by the absence of these teeth.

A total of 44 dental arch widths, lengths, and tooth size measurements were obtained on the maxillary and mandibular dental casts at each of the two stages. These measurements included:

- Intercanine and intermolar widths.
- Anterior, posterior, and total arch lengths (circumference), measured from the mesial of the permanent first molar to the mesial of the canine, (posterior arch length) and from the mesial of the canine to the midline (anterior arch length) on both sides of the arch.
- The mesiodistal diameter of each tooth mesial to the permanent first molars measured at both the younger and the older ages. The mesiodistal crown diameter was considered to be the distance between the anatomic contact points.^{13,14} When restorations differed from normal contours, the affected measurements were discarded for the purpose of measuring the mesiodistal crown diameter.
- Total tooth size-arch length discrepancy (TSALD), determined by subtracting the sum of the crown sizes of the teeth anterior to the permanent first molars from the total arch length.
- Anterior TSALD, determined by subtracting the sum of the size of the teeth anterior to (but not including) the first premolars from the anterior arch length.

A negative value reflected crowding and a positive value reflected spacing. Crown size measurements at the younger age were used to calculate TSALD at the younger age; likewise, crown size measures at the older ages were used to calculate TSALD at the older age.

Reliability of the measurements

Dental cast landmarks were digitized and recorded with a Reflex Metrograph (Reflex Metrograph-4, Ross Instruments Limited, Salisbury, England). Each dental cast was digitized on two separate occasions, and when arch measurements differed by more than 0.25 mm, the cast was redigitized.

Table 2
Descriptive and comparative statistics on the dental arch measurements of male subjects at 25 and 45 years of age.

Variable	25 years				45 years				Change				P
	$\bar{x}$	SD	Range		$\bar{x}$	SD	Range		$\bar{x}$	SD	Range		
Overbite	2.6	1.6	-0.2	5.9	3.0	1.7	0.4	6.9	0.4	1.0	-1.4	1.9	0.1635
Overjet	2.3	1.6	-1.7	6.1	2.7	1.5	-2.0	4.7	0.4	1.2	-3.3	2.5	0.2354
Maxillary													
Anterior arch length	44.9	3.0	39.0	49.8	44.2	3.1	37.2	49.2	-0.7	0.6	-2.0	0.2	0.0010**
Total arch length	73.2	4.4	67.0	80.3	72.2	4.5	64.6	79.3	-1.0	0.9	-3.0	0.2	0.0007**
Anterior TSALD	-1.5	1.3	-3.3	1.0	-1.9	1.8	-5.3	1.2	-0.4	0.7	-0.9	2.1	0.0577
Total TSALD	-0.4	2.2	-2.4	4.3	-1.0	2.6	-4.3	4.1	-0.6	0.8	-1.4	2.0	0.0116*
Intercanine width	34.0	2.3	30.5	37.8	33.7	2.3	28.7	37.1	-0.4	0.8	-1.8	1.6	0.1179
Intermolar width	53.6	2.8	47.4	58.0	53.4	2.7	48.2	58.0	-0.2	0.9	-2.1	1.0	0.4928
Mandibular													
Anterior arch length	33.9	3.0	28.8	40.2	32.7	2.3	28.6	37.4	-1.2	1.6	-5.9	0.3	0.0144*
Total arch length	62.3	4.2	55.3	69.2	61.7	4.3	54.4	68.6	-1.2	0.9	-2.8	-0.1	0.0008**
Anterior TSALD	-1.8	2.2	-5.1	3.5	-2.7	1.9	-6.4	0.1	-0.9	1.7	-0.7	5.9	0.0479*
Total TSALD	-1.5	2.0	-5.2	1.7	-2.5	2.3	-5.8	1.7	-0.9	0.9	-0.4	2.5	0.0052
Intercanine width	25.2	1.8	20.8	27.4	24.8	1.7	20.9	27.1	-0.4	0.4	-1.2	0.3	0.0029**
Intermolar width	46.0	3.0	38.5	49.4	45.7	3.2	38.0	50.0	-0.3	0.5	-0.8	0.6	0.4025

$\bar{x}$ = mean; SD = standard deviation; P = probability

Mesiodistal crown diameters were measured directly from the casts using a dial caliper accurate to 0.05 mm. (Mitutoyo Corporation, Tokyo, Japan).

Statistical analysis

Descriptive statistics obtained included the mean, standard deviation, and minimum and maximum values for each parameter measured at each age and the change in each parameter between the two ages.

Paired *t*-tests were used to determine the level of statistically significant differences within each parameter between the two ages. Independent *t*-tests were used to determine significant differences in the parameters between sexes.¹⁵ The level of significance was predetermined at the 0.05 level of confidence.

Results

Dental arch changes with age (Tables 2 and 3)

Overbite increased significantly with age in females ($\bar{x} = 1.0 \pm 0.5$ mm) but not in males ($\bar{x} = 0.4 \pm 1.0$). On the other hand, overjet did not change significantly in either males or females.

A significant decrease was observed in maxillary (-0.4 ± 0.6 mm) and mandibular (-0.6 ± 0.4 mm) intercanine arch widths in females and mandibular (-0.4 ± 0.4 mm) intercanine width in males.

All arch length measurements decreased significantly with age in both males and females. In addition, maxillary and mandibular anterior TSALD increased significantly.

Male-female comparisons

Absolute differences: Except for mandibular canine arch width, all dental arch width measurements were significantly larger in males than in females at both the younger and older ages.

Incremental differences: The differences in the changes in overbite or overjet for males and females were not statistically significant. There was no tendency for arch width changes in either sex to be consistently greater than or significantly different from the changes in the other sex. In females, maxillary intermolar arch width tended to increase slightly (0.1 ± 0.6 mm). In males, both maxillary and mandibular intermolar arch widths tended to decrease. When compared with each other, males and females did not have significantly greater changes in dental arch lengths or TSALD. The changes in both sexes were expressed predominantly as a decrease in length and an increase in total TSALD.

Changes in the dentition (Table 4)

Comparisons between males and females at stages 1 and 2 regarding the number of teeth extracted, number of fillings and crowns present as well as the changes in the size of the fillings indicated that there were no statistically significant differences ($P > 0.05$) between the sexes in any of the parameters compared. On the other hand, both males and females showed significant ($P < 0.05$) increases in the number of restorations, the size of the restorations, and the number of crowns.

Table 3
Descriptive and comparative statistics on the dental arch measurements of female subjects at 25 and 45 years of age.

Variable	25 years				45 years				Change				P
	$\bar{x}$	SD	Range		$\bar{x}$	SD	Range		$\bar{x}$	SD	Range		
Overbite	2.9	2.0	-1.1	6.2	3.7	1.9	0.7	7.6	1.0	0.5	0.2	1.9	0.0001**
Overjet	3.1	1.1	0.8	5.0	3.3	0.8	2.5	5.0	0.2	-1.2	2.0	0.2921	
Maxillary													
Anterior arch length	43.6	2.2	40.2	47.5	43.2	2.2	38.8	46.6	-0.5	0.7	-1.8	0.7	0.0209*
Total arch length	71.1	2.7	66.5	76.8	70.1	3.1	65.9	74.6	-1.0	1.0	-2.5	0.9	0.0057**
Anterior TSALD	-1.8	1.3	-4.0	-0.5	-2.0	1.6	-5.5	0.8	-0.2	0.6	-0.5	1.5	0.2535
Total TSALD	-0.6	1.9	-3.6	3.2	-0.7	2.0	-5.0	4.0	-0.1	1.0	-1.8	1.8	0.7612
Intercanine width	32.3	1.8	29.1	35.4	31.9	2.0	28.3	35.8	-0.4	0.6	-1.8	0.4	0.0190*
Intermolar width	48.3	1.6	46.0	50.9	48.4	1.6	45.7	51.4	0.1	0.6	-0.8	1.1	0.4094
Mandibular													
Anterior arch length	32.8	1.9	29.8	36.5	32.1	1.7	29.8	34.7	-0.7	0.7	-2.1	0.1	0.0013**
Total arch length	59.5	3.3	54.0	67.0	58.6	3.2	52.6	65.3	-0.8	0.9	-2.0	1.2	0.0099*
Anterior TSALD	-3.0	1.8	-7.2	-0.2	-3.5	2.0	-7.5	-1.0	-0.6	0.8	-1.0	2.0	0.0132*
Total TSALD	-3.4	1.4	-5.2	-1.1	-4.0	1.6	-6.1	-1.3	-0.6	1.0	-0.9	2.1	0.0701
Intercanine width	24.4	1.4	20.9	26.3	23.8	1.4	21.0	26.2	-0.6	0.4	-1.3	0.2	0.0002**
Intermolar width	41.5	2.3	37.6	45.5	41.5	2.6	36.8	45.7	0.1	1.0	-0.9	2.4	0.7004

$\bar{x}$ = mean; SD = standard deviation; P = probability

In the total sample, at age 25 years, 33% of the subjects had no third molars. By age 45 years, another 25% had their remaining third molars removed. In the other 42% of the subjects, anywhere from 1 to 4 third molars were still present.

Other than third molars, there was an average tooth loss of 0.3 in males (total of 5 teeth in 15 males) and 0.1 in females (total of 2 teeth in 15 females), over the 20-year period. Males had an average of 2.1 new fillings while females had 1.3. In addition, males had on the average 2.3 new crowns while females had 1.9.

Discussion

Long-term aging studies are inherently difficult to conduct, particularly in relatively mobile populations. As a result such studies have a number of limitations, including small sample size, wide variation in the ages of the subjects, different time spans between the examination intervals, and inclusion of 17-18 year-olds for whom later adolescent growth was still possible.^{2-7,16-23} In the present study, an attempt was made to include subjects who, at the initial evaluation, had passed adolescence and were in their early adulthood and who fell into a narrowly defined age range. The follow up examination interval was approximately 20 years (Table 1).

The findings in this study indicate that a number of changes occur between early and midadulthood in various parameters.

Dental arch widths: In general, males had significantly wider dental arch dimensions than fe-

males, except for mandibular intercanine width, which was not significantly different. One could assume that to some degree, dental arch width reflects the size of the underlying basal bone. Since males in general are larger than females, their greater dental arch width in adulthood is not surprising. On the other hand, crowding would tend to diminish the anterior dental arch width more than posterior arch width, which might explain why no significant male-female differences were seen in mandibular intercanine width. In general, the differential change in arch width observed in the present study agrees with that of Lundström⁸ who found that the maxillary arch width at the first molars exhibited a 0.2 mm increase. On the other hand, mandibular arch width at the first molars did not change.

Dental arch lengths (circumference): Although males consistently had larger arch lengths, differences in age changes between males and females were not significant. Dental arch length measures are based on the space occupied by tooth substance and not primarily on the absolute size of the basal bone. Therefore, unless there are also significant tooth size differences between the sexes or differences in tooth alignment, no substantial differences in dental arch length decrease should be expected. For all the measured mesiodistal crown diameters anterior to the first molars, only the canines in males are significantly larger than those of females.

Tooth size-arch length discrepancy: The increase in crowding seen in the anterior part of

Table 4
Descriptive statistics on the status of the dentition at the two stages evaluated within a 20-year period.

Parameter	Stage 1				Stage 2				Stage 1 - 2		P
	Males x SD	Females x SD	Males x SD	Females x SD	Males x SD	Females x SD	Males x SD	Females x SD			
Third molars present	2.5 1.4	1.4 1.6	1.5 1.4	0.5 1.1	-1.0 1.6	NS	-0.9 1.5	NS			
Other tooth loss	0.6 1.4	1.0 1.4	0.8 1.5	1.1 1.4	-0.3 0.7	NS	-0.1 0.4	NS			
Restorations											
Fillings	12.7 6.4	12.7 3.4	14.8 6.5	14.0 3.1	2.1 2.2	S**	1.3 1.2	S**			
Change in size											
Crowns	0.8 1.3	0.7 1.3	3.1 2.7	2.6 3.8	1.4 1.2	S*	2.6 1.9	S**			
					2.3 2.3	SII	1.9 2.9	NS			

$\bar{x}$ = mean; SD = standard deviation; P = probability; * = significant ≤ 0.01 ; NS = not significant

the arch constitutes the largest portion of the increase in the total crowding seen in the entire arch. A significant increase in TSALD was found in the mandibular anterior segments, and for the total maxillary and mandibular arches in both males and females.

Lundström⁸ also found that more subjects had increases in mandibular arch crowding than in the maxillary arch.

Other dental findings: As expected, over the 20-year period, there were statistically significant increases in the number and size of restorations, the number of crowns, and tooth loss. In general, the frequencies of these occurrences were greater in males than in females. Although both males and females had maintained their dentition in fairly good condition, females had less dental disease that needed restorative care. Regardless, the findings indicate that, in general, the dentition was in a state of good repair and the dental arch changes were not related to decay or tooth loss.

Clinical implications

The present findings suggest that age-related changes in the dental arches do not cease to occur with the onset of adulthood, but continue, albeit at a significantly slower rate, throughout adult life. With a few important exceptions, these changes tend to be, on the average, of small magnitude (< 1.0 mm), so that their clinical relevance is somewhat limited, and generally would not significantly influence orthodontic treatment planning.

The findings that are considered to be clinically pertinent include: decreases in intercanine arch width and total arch length (circumference) as well as increases in mandibular anterior TSALD and total TSALD in both arches in males and females. Clearly, these findings have important clinical implications regarding the long-range stability and retention of the orthodontic treatment results.

In an earlier study on the same population, tooth size-arch length discrepancies increased from early adolescence (14 years of age) until early adulthood (25 years of age)¹⁸ When these earlier changes in the anterior TSALD are included, the total change amounts to 2.7 mm of crowding in the mandibular arch and 1.9 mm in the maxillary arch in males. The corresponding changes in females are 3.5 mm and 2.0 mm, respectively. If these findings can be extrapolated to orthodontically-treated adolescents and young adult patients, one may speculate that without long-term retention, patients treated to a well-aligned dentition should expect various amounts of crowding to occur in the anterior part of the dental arches. This should be regarded as part of the "normal" maturation process, regardless of the initial malocclusion or how well treated these cases were at the time the orthodontic appliances were removed.

Conclusions

1. In general, overjet did not significantly change with age in either males or females while

overbite significantly increased in females.

2. Males had wider arches and a tendency for longer arches.

3. Both sexes experienced a significant increase in dental crowding in both arches. The severity of the crowding differed in each arch and in each sex; but was more pronounced in the mandibular anterior segments.

4. In both sexes, over the span of this study, anterior intercanine width significantly decreased while arch length (circumference) losses occurred in both the anterior and posterior segments.

5. Differences between males and females in the magnitude of changes seen in arch widths and lengths were not statistically significant.

6. In both males and females the number of restorations (fillings and crowns) increased but minimal tooth structure was lost through extractions, except for third molars.

Overall, the findings of this study suggest that age-related changes in the dental arches do not cease with the onset of adulthood, but continue, albeit at a slower rate, throughout adult life.

Author address

Dr. Samir E. Bishara
University of Iowa
College of Dentistry
Department of Orthodontics
220 Dental Science S.
Iowa City, IA 52242-1001
Samir E. Bishara, professor of orthodontics, College of Dentistry, University of Iowa, Iowa City, Iowa.
Jean E. Treder is in private practice in Iowa City, Iowa.
Paul Damon is in private practice in Seattle, Wash.
Mark Olsen, graduate student, Indiana University.

References

1. Meredith HV. Toward a working concept of physical growth. *Am J Orthod Oral Surg* 1945;31:440-58.
2. Barrow GC, White JR. Developmental changes of the maxillary and mandibular dental arches. *Angle Orthod* 1952;22(1):41-6.
3. Bishara SE, Jakobsen JR, Treder JE, Stasi MJ. Changes in the maxillary and mandibular tooth size-arch length relationship from early adolescence to early adulthood. A longitudinal study. *Am J Orthod Dentofac Orthop* 1989;95(1):46-59.
4. DeKock WH. Dental arch depth and width studies longitudinally from 12 years of age to adulthood. *Am J Orthod* 1972;62(1):56-66.
5. Moorrees CFA, Gron AM, Lebet LML, Yen PKJ, Frohlich FJ. Growth studies of the dentition: a review. *Am J Orthod* 1979;55:600-16.
6. Richardson M. Lower arch crowding in the young adult. *Am J Orthod Dentofac Orthop* 1992;101(2):132-7.
7. Sillman JH. Dimensional changes of the dental arches: longitudinal study from birth to 25 years. *Am J Orthod* 1964;50:824-42.
8. Lundstrom A. Changes in crowding and spacing of the teeth with age. *Dent Practit* 1969;19(6):218-24.
9. Burt BA, Ismail AI, Morrison EC, Beltran ED. Risk factors for tooth loss over a 28-year period. *J Dent Res* 1990; 69(2):430-435.
10. Ismail AI, Morrison EC, Burt BA, Caffessa RG, Kavanagh MT. Natural history of periodontal disease study in adults. Findings from the Tecumseh Periodontal Disease Study, 1959-87. *J Dent Res* 1990;69(2):430-435.
11. Chauncey HH, Glass RL, Alman JE. Principal cause of tooth extraction in a sample of US male adults. *Caries Res* 1989;23:200-205.
12. Knott VB. Longitudinal study of dental arch widths at four stages of the dentition 1972, 42:387-94.
13. Fuller JL, Denehy GE. Concise dental anatomy and morphology. Chicago: Yearbook Medical Publishers, 1979.
14. Hunter WS, Priest WR. Errors and discrepancy in measurement of tooth size. *J Dent Res* 1960;39:405-14.
15. SAS user's guide. Raleigh, North Carolina: 1979.
16. Behrents RG. An atlas of growth in the aging craniofacial skeleton. Monograph 18, Craniofacial Growth Series. Ann Arbor: Center for Human Growth and Development, University of Michigan, 1985.
17. Behrents RG. Adult facial growth. In: Enlow DH, ed. Facial growth. 3rd ed. Philadelphia:WB Saunders, 1990.
18. Christie TE. Cephalometric patterns of adults with normal occlusion. *Angle Orthod* 1977;47(2):128-35.
19. Forsberg CM. Facial morphology and ageing: a longitudinal cephalometric investigation of young adults. *Eur J Orthod* 1979;1:15-23.
20. Israel H. Age factor and the pattern of change in craniofacial structures. *Am J Phys Anthropol* 1973;39:111-28.
21. Israel H. Age factor and the pattern of change in craniofacial structures. *Am J Phys Anthropol* 1973;39:111-28.
22. Kendrick GS, Risinger HL. Changes in the antero-posterior dimensions of the human male skull during the third and fourth decade of life. *Anat Rec* 1967;159:77-81.
20. Lewis AB, Roche AF. late growth changes in the craniofacial skeleton. *Angle Orthod* 1988;58(2):127-35.
21. Tallgren A. Neurocranial morphology and ageing — a longitudinally roentgen cephalometric study of adult Finnish women. *Am J Phys Anthropol* 1974;41:285-93.