Original Article

Aging in the Craniofacial Complex

Longitudinal Dental Arch Changes Through the Sixth Decade

Marcus M. Dager[a]; James A. McNamara[b]; Tiziano Baccetti[c]; Lorenzo Franchi[c]

ABSTRACT

Objective: To describe the dental arch changes occurring after adolescence through the sixth decade of life.

Materials and Methods: Longitudinal dental casts from 40 patients (20 male and 20 female) were digitized and analyzed. Measurements were recorded after the presumed cessation of circumpubertal growth (T1), at approximately 47 years of age (T2), and at least one decade later (T3) were compared.

Results: The majority of the measurements were found to have a significant time effect, demonstrating at least some level of change throughout the aging process (T_1–T_3). Exceptions to this observation were the posterior maxillary arch width measurements, mandibular intermolar and interpremolar (as measured at the second premolars) widths, the maxillary incisor irregularity index, overjet, overbite, and curve of Spee. The T_1–T_3 changes reflected for the most part the T_1–T_2 changes, while the T_2–T_3 changes affected overall modifications only for the mandibular intercanine width and maxillary depth, as measured at the second premolars. All changes reflected a decrease in arch width, depth, and perimeter, with a significant increase in the mandibular incisor irregularity index.

Conclusions: The dental arches continue to change and adapt throughout life and into the sixth decade, though the degree of change decreases with time.

KEY WORDS: Dentition; Maturational changes; Dental casts; Digital imaging; Craniofacial growth

INTRODUCTION

It is a commonly held belief that the morphology of the dental arch is dictated by the supporting alveolar bone from which it arises[1] and that this form is modified further in all three planes of space by intraoral functional forces and the circumoral musculature.[2,3] Perhaps the most important factor in the observed changes in these somewhat malleable structures, however, is the fourth dimension (ie, time).

A number of recent studies[4–8] have documented significant changes occurring in the dentofacial complex continuing into adulthood. The sum of these studies is that the form, function, size, and shape of the components continue to reflect small, but often statistically significant changes. Among these studies, only Harris[8] has attempted to describe dental arch changes as late as the sixth decade. However, as this study measured subjects at approximately 20 years of age and again at approximately 55 years of age without intermediate measurements, it is impossible to isolate those changes occurring exclusively during the latest years of the investigation.

To meet the increasing need in an older orthodontic population,[9] it is necessary to examine and describe the normal aging process of the dental arches contained within the adult craniofacial complex. Consequently, the present study was designed to detail the dental changes associated with aging, particularly

[a] Private Practice, Indianapolis, Ind.

[b] Thomas M. and Doris Graber Endowed Professor of Dentistry, Department of Orthodontics and Pediatric Dentistry, School of Dentistry; Professor of Cell and Developmental Biology, School of Medicine; and Research Professor, Center for Human Growth and Development, The University of Michigan, Ann Arbor, Michigan. Private practice of orthodontics, Ann Arbor, Mich.

[c] Assistant Professor, Department of Orthodontics, University of Florence, Firenze, Italy, and Thomas M. Graber Scholar, Department of Orthodontics, University of Michigan, Ann Arbor, Mich.

Corresponding author: Dr James A. McNamara, The University of Michigan, Department of Orthodontics and Pediatric Dentistry, 1011 North University, Ann Arbor, MI 48109-1078 (e-mail: mcnamara@umich.edu)

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Table 1. Distribution of Samples by Age

	Male Subjects				Female Subjects				Pooled Subjects			
	N	Age Range, y	Mean	SD	N	Age Range, y	Mean	SD	N	Age Range, y	Mean	SD
T_1	20	14.9–18.0	17.0	0.9	20	14.8–18.1	16.9	0.8	40	14.8–18.1	17.0	0.9
T_2	20	41.2–54.8	47.3	4.1	20	40.1–51.8	47.6	3.5	40	40.1–54.8	47.5	3.7
T_3	20	52.3–66.7	58.4	4.2	20	51.4–62.9	58.7	3.3	40	51.4–66.7	58.6	3.8

those occurring after adolescence, with special attention to those changes occurring in the sixth decade of life.

MATERIALS AND METHODS

Patient Sample

The subjects for the current investigation were previous participants in the University of Michigan Elementary and Secondary School Growth Study (UMGS).[10,11] Those subjects who had been successfully recalled in a previous survey in 1995[5,7] and who also had diagnostic records available from the late teen years were targeted. Of these 65 subjects, nine could not be located, four declined to participate, and six could not make arrangements for their records to be obtained in a timely manner. Further, one subject was excluded due to multiple extractions, one had received extensive prosthodontic reconstruction, and four subjects were excluded whose records were damaged or incomplete. Therefore, the final number of subjects for the current study was 40 (20 male, 20 female; Table 1).

The sample originally was divided according to orthodontic treatment status. For the purposes of this study, ‘‘orthodontic treatment’’ was defined as any orthodontic intervention in either arch beyond space maintenance including expansion, functional appliances, active removable appliances, overbite/overjet correction appliances, or full orthodontic appliances. In all treated subjects orthodontic treatment and retention were completed prior to the time of first observation (T_1). Final samples comprised 12 male subjects and 10 female subjects in the untreated group, and 8 male subjects and 10 female subjects in the treated group.

Dental Cast Analysis

The dental casts of these subjects were measured using a digital imaging system (Bioscan OPTIMAS Imaging System, version 6.51.199; Seattle, Wash). This system was adapted to enable acquisition and measurement of dental cast data by Brust and McNamara,[12] and further modified for the adult dentition by Carter and McNamara.[5] Methods for image capture and landmark acquisition have been described in detail in previous publications.[5,12] Definitions of arch depth, width, and perimeter reflect those described by O'Grady and associates.[13]

Due to the limitations of the OPTIMAS system, overbite, overjet, and curve of Spee were measured directly from the dental casts with the use of a digital caliper (Dentagauge 3, Erskine Dental, Marina Del Rey, Calif). Overbite was calculated by averaging the distance from the incisal edge of each maxillary incisor to the incisal edge of the corresponding mandibular incisor, measured perpendicular to the occlusal plane when the casts were oriented in centric occlusion. Overjet was calculated by averaging the distance from the labial surface of each mandibular incisor to the labial surface of its corresponding maxillary incisor measured parallel to the occlusal plane when the casts were oriented in centric occlusion. Curve of Spee, the perpendicular distance from a flat plane constructed over the incisal edges of mandibular incisors to the cusps of mandibular first molars, was calculated by averaging the greatest distances from cusp tips to the plane on the right and left sides.

At random intervals during digitization, measurements obtained through the OPTIMAS system were verified through the use of direct dental cast measurements. Comparison of these values found them to be consistent throughout the investigation.

Error of the Method

Ten dental casts were selected at random to duplicate measures. Intraclass correlation coefficient values ranged from 0.947 (maxillary incisor irregularity) to 0.999 (mandibular first interpremolar width, overbite). Dahlberg's formula[14] yielded standard error values ranging from 0.07 mm (overjet) to 0.42 mm (maxillary incisor irregularity index).

Statistical Analysis

Descriptive statistics. Mean and standard deviation for each of the measured parameters were calculated at three time points: after the presumed cessation of circumpubertal growth (T_1), at approximately 47 years of age (T_2), and at least one decade later (T_3). Mean differences and standard deviations were calculated for changes over time (T_1–T_2, T_2–T_3, and T_1–T_3).

Inferential statistics. After confirming a normal distribution of the dental arch variables of the sample

Table 2. Pooled Sample: Descriptive and Inferential Statistics (N = 40)

	T_1		T_2		T_3		T_1–T_2		T_2–T_3		T_1–T_3	
Measurement, mm	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Maxillary arch width (centroid)												
First intermolar	42.0	2.5	41.8	2.5	41.9	2.7	−0.3	0.8	0.2	0.5	−0.1	1.1
Second interpremolar	37.3	2.1	37.1	2.3	37.3	2.4	−0.2	0.7	0.2	0.5	0.0	0.9
First interpremolar	32.8	1.8	32.6	2.0	32.6	2.2	−0.2	0.8	0.1	0.4	−0.2	0.9
Intercanine	29.0	1.4	28.4	1.5	28.4	1.7	−0.6**	0.6	0.0	0.4	−0.6**	0.8
Mandibular arch width (centroid)												
First intermolar	39.3	1.9	39.2	2.2	39.5	2.4	−0.1	0.8	0.2	0.6	0.2	1.0
Second interpremolar	34.0	1.9	33.6	2.0	33.7	2.2	−0.3**	0.7	0.1	0.5	−0.3	0.9
First interpremolar	29.4	1.4	28.8	1.5	28.7	1.7	−0.6**	0.6	−0.1	0.4	−0.7**	0.7
Intercanine	22.4	1.3	21.6	1.5	21.4	1.6	−0.8**	0.7	−0.2*	0.3	−1.0**	0.8
Maxillary arch depth												
First molar	25.1	2.0	23.8	2.1	23.7	2.0	−1.2**	0.8	−0.2	0.5	−1.4**	0.9
Second premolar	19.1	1.8	18.1	1.9	17.9	1.8	−1.1**	0.8	−0.2*	0.4	−1.3**	0.8
First premolar	13.1	1.4	12.2	1.4	12.0	1.4	−1.0**	0.7	−0.2	0.5	−1.2**	0.8
Canine	6.2	1.3	5.6	1.4	5.5	1.3	−0.6**	0.7	−0.1	0.5	−0.7**	0.6
Mandibular arch depth												
First molar	20.4	1.8	19.2	1.7	19.0	1.6	−1.2**	0.7	−0.2	0.7	−1.4**	1.0
Second premolar	14.4	1.8	13.3	1.7	13.2	1.6	−1.1**	0.8	−0.1	0.5	−1.2**	0.9
First premolar	8.5	1.3	7.7	1.2	7.6	1.3	−0.8**	0.7	−0.1	0.4	−0.9**	0.8
Canine	3.1	0.8	2.6	0.9	2.6	1.0	−0.5**	0.6	0.0	0.4	−0.5**	0.8
Arch perimeter												
Maxillary	69.2	3.8	67.1	3.7	66.9	3.7	−2.1**	1.6	−0.2	0.6	−2.2**	1.8
Mandibular	59.5	3.2	57.6	3.1	57.0	3.1	−1.8**	1.8	−0.6	1.5	−2.4**	1.3
Incisor irregularity index												
Maxillary	3.6	1.4	4.2	1.9	4.2	1.7	0.7	1.8	0.0	1.1	0.7	1.9
Mandibular	4.0	2.2	5.4	2.4	5.8	2.9	1.4**	1.8	0.4	2.2	1.8**	2.8
Overjet	4.4	1.4	4.4	1.5	4.4	1.6	0.0	0.7	0.0	0.4	0.0	0.8
Overbite	3.1	1.2	3.2	1.5	3.3	1.6	0.1	1.0	0.1	0.5	0.2	1.1
Curve of Spee	1.0	0.5	1.1	0.6	1.1	0.6	0.0	0.4	0.0	0.2	0.0	0.4

* $P < .05$; ** $P < .01$ using Bonferroni's correction for multiple comparisons.

through a Shapiro-Wilks test, data were analyzed through the use of repeated measures analysis of variance (RMANOVA) designed to test for the effects of time, orthodontic treatment, and gender. A nominal α level of .05 was selected and adjusted to .05/3 = 0.017 using Bonferroni's correction for multiple comparisons.

RESULTS

Analysis of Interactions

In an analysis comprising 23 arch parameters, only maxillary intercanine width demonstrated a statistically significant time × treatment × gender interaction ($P <$ .05). No measurements in this investigation demonstrated statistical significance of either a treatment × time or a treatment × gender interaction, meaning that the study did not find differences in the way that orthodontically treated or untreated subjects age with respect to their dental alignments, and the effects of orthodontic treatment were not shown to differ based on gender. The effect of gender consistently showed larger dimensions for male subjects compared with female subjects, without any qualitative consequence on the interpretation of the results. Thus, data from male and female subjects, as well as from treated and untreated subjects, were pooled for the purpose of analysis. Descriptive and inferential statistics for the pooled male and female samples are presented in Table 2.

Effects of Time (Aging)

The majority of the measurements examined were found to have a significant time effect, demonstrating at least some level of change throughout the aging process (T_1–T_3). Exceptions to this observation were the posterior maxillary arch width measurements, mandibular intermolar and interpremolar (as measured at the second premolars) widths, the maxillary incisor irregularity index, overjet, overbite, and curve of Spee. The T_1–T_3 changes reflected, for the most part, the T_1–T_2 changes, while T_2–T_3 changes affected overall modifications only for the mandibular intercanine width and maxillary depth, as measured at the second premolars. All changes reflected a decrease in arch width, depth, and perimeter, with a significant increase in mandibular incisor irregularity index (Table 2).

DISCUSSION

The purpose of this study was to describe the dental arch changes effected throughout adulthood, with a focus on those within the sixth decade of life. Subjects were selected from those who had participated in previous recalls of the University of Michigan Elementary and Secondary School Growth Study.

Overall, the changes observed from T_1 to T_2 are those that would contribute to crowding in the dental arches. Maxillary and mandibular arch width and depth decreased nearly universally, as did arch length. Accordingly, incisor irregularity increased in both arches, though this change was significant only in the mandible. Despite the significant changes in these arch dimensions, remarkable stability was observed in overbite, overjet, and curve of Spee during this time. The vast majority of statistically significant changes throughout the investigation occurred from T_1 to T_2, representing the 30-year period from approximately 17 to 47 years of age.

In contrast to the preceding three decades, the period from 47 to 58 years of age was characterized by little change, if any. In general, arch depth and length continued to decrease from T_2 to T_3, though to a lesser degree than observed from T_1 to T_2, resulting in a change that often was not statistically significant during this time period. From T_2 to T_3, only two arch width measurements (mandibular second premolar and first molar widths) showed significant changes (0.2 mm), though still probably below the definition of clinical significance.

Maxillary intercanine width was the only parameter in the present study that demonstrated a significant three-way interaction between time, gender, and treatment. No significant change was observed in untreated female subjects (T_1–T_2 = −0.2 mm; T_1–T_3 = −0.1 mm), while a significant decrease in intercanine width was apparent in untreated males (T_1–T_2 = −0.8 mm, $P < .01$; T_1–T_3 = −0.9 mm, $P < .01$). Ignoring the treatment effect, maxillary intercanine width decreased significantly in both male and female subjects between T_1 and T_2 (−0.8 mm and −0.5 mm, $P < .01$, respectively), as well as between T_1 and T_3 (−0.6 mm, $P <$ .01, in both groups). On average, male subjects demonstrated a greater constriction of intercanine distance over time compared to female subjects, in agreement with findings published by Carter and McNamara,[5] but in contrast to results presented by Harris.[8] No significant changes were noted between 47 and 58 years of age in the present study, an apparent continuation of the stability suggested by Bishara et al[15] for this dimension. Maxillary intermolar width did not change significantly throughout the present study, in concordance with all studies with the exception of the 1997 investigation performed by Harris[8] in which he describes significant increases in all maxillary dental widths through age 55 years.

The dental arches demonstrated a relative constriction in the anterior segment with time. It can be seen that both arches would take on a more rounded form through these changes in association with significant decreases in maxillary and mandibular arch depths. This result is in agreement with a study published by Henrikson and coworkers[16] who found that the changes in arch form from adolescence into adulthood could be related to a decrease in arch depth, with greater increases over time of the premolar region with respect to intercanine width. The decrease in arch depth was accompanied by significant decreases in both maxillary and mandibular arch perimeters, and by a significant increase in incisor irregularity index limited to the mandibular arch.

The present investigation showed no significant changes in the curve of Spee between T_1 and T_2 or between T_2 and T_3. Carter and McNamara[5] described a decrease in the curve of Spee in untreated male subjects between 13.8 and 17.2 years of age, but determined the curve of Spee to be unchanged thereafter. Studies by Bishara and his groups[17] demonstrated mild decreases in the curve of Spee. A striking majority of the sample utilized in this study demonstrated marked attrition of the mandibular incisors, a feature that would result in a decreased measurement of the curve of Spee. One could suggest that the incisor wear is secondary to traumatic occlusion due to incisor extrusion associated with the increased curve of Spee. It also could be hypothesized, however, that the incisors extrude secondary to incisal edge wear in order to reestablish occlusal contact with the opposing arch.

The present investigation noted no significant change in overbite throughout the course of the study. This observation is in agreement with the study by Harris[8] and would appear to be a continuation of the trend toward stability described by Forsberg.[18] A study by Tibana and coworkers[19] suggests that overbite may increase during early adulthood, while investigations by Bishara and coworkers[4] and Akgul and Toygar[20] found this increase to be significant only in female subjects. The small changes described in the existing literature and in the present study were of no clinical significance. Throughout the present investigation, overjet was found to remain essentially unchanged. None of the changes observed were statistically significant. These results are in agreement with those of all longitudinal studies of overjet in early[4,19,21,22] and middle adulthood[5,7,8,21] that have shown agreement in their reports of stability of this measurement over time.

The present investigation revealed few statistically significant changes between the ages of 47 and 58 years. To make a claim of clinical significance of any of these changes may be unwise. The largest linear change observed was approximately 0.5 mm over a 10-year period (ie, 0.6 mm decrease in mandibular arch perimeter). However, a comparison of the values from T_2 to T_3 appears to reflect a continuation of the trends established between T_1 and T_2, suggesting that while the arches are changing only slightly, these changes may be considered predictable to some degree.

CONCLUSIONS

- The dental arches continue to change throughout adulthood and into the sixth decade of life. These changes in arch width, depth, and length are decremental, and they reflect a continuation of those trends documented in the years prior to the sixth decade, though the degree of change decreases with time.
- There exists a tendency toward more rounded arch forms with age. This change in arch form results from a significant decrease in maxillary and mandibular arch depths.

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