Maturation of untreated normal occlusions

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The dental casts of 65 untreated normal occlusions were evaluated to determine the nature and extent of the developmental maturation process of the normal dentition. Six dental parameters were examined in the mixed dentition (9 to 10 years), early permanent dentition (12 to 13 years), and early adulthood (19 to 20 years). Results showed decreases in arch length and intercanine width; minimal overall changes in intermolar width, overjet, and overbite; and increases in incisor irregularity. Females showed more severe changes than males. The individual changes found were not correlated to changes in any of the other parameters measured. No associations or predictors of clinical value were found. The changes found in a sample of untreated normals were similar in nature but lesser in extent than postretention changes found in a sample of treated cases.

Key words: Untreated normal occlusions, dental maturation, sexual dimorphism, postretention

Relapse, physiologic recovery, rebound, postretention settling, and other terms describing change of the treated orthodontic case conjure up good and bad memories for orthodontic practitioners. We may tend to revel, document, and display those cases that remain nearly unaltered with time as examples of our prowess and skill. Other cases never completed to a stage of the ideal may surprisingly improve with age. But the discouragement of deteriorating results for well-treated cases leads to the most frustration. Through experience we anticipate certain relapse changes, given the compromises involved in treatment, the original problem, unfavorable cooperation or growth, etc., but relapse can occur unexpectedly and may seem to defy explanation.

Many theories have been proposed as to the etiology of relapse and many treatment and retention strategies have been devised in an attempt to minimize undesirable posttreatment changes.[1] Unfortunately most of these theories and clinical guidelines were based on personal experience and bias, with little or no objective documentation to support them. The results of long-term longitudinal studies[2–5] have started to cast some light on the posttreatment and postretention changes seen in orthodontically treated cases. In general, these studies have tended to show continuing decrease in arch width and arch length after treatment, with increases occurring in incisor crowding, overjet, and overbite.

The problem has been the inability to determine whether these changes occurred primarily as a result of the orthodontic therapy or were part of the normal developmental maturation process. As stated by Horowitz and Hixon,[6] "The significant point is that orthodontic therapy may temporarily alter the course of these continuous physiologic changes and possibly, for a time, even reverse them; however, following mechanotherapy and the period of retention restraint, the developmental maturation process resumes."

Documentation and review of serial records involving untreated cases followed through the mixed-dentition period into adulthood should offer clues, but at least two different samples must be evaluated: untreated normal occlusions and untreated malocclusions. The purpose of the present study was threefold: (1) to describe the nature and extent of the dental changes seen during development from the mixed dentition into adulthood in untreated normals; (2) to analyze relationships between the variables measured in an effort to identify trends, predictors, and associations of clinical value; and (3) to compare the dental changes seen in similar treated and untreated groups.

Growth direction and amount have been implicated as being associated with alignment change vs. stability. Perhaps a highly complex and intricate interaction of numerous craniofacial and dental matrices are involved as factors predisposing to crowding during the normal growth process. Study of such an interaction will be

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dealt with in a subsequent article utilizing this same sample of untreated cases.

REVIEW OF THE LITERATURE

In a longitudinal study of dental development between the ages of 3 and 18, Moorrees[7] found that the mandibular intermolar distance increased between the ages of 9 and 14 in both sexes but that thereafter it remained constant. Arch length decreased in both males and females, with the greatest decrease occurring between 9 and 14, corresponding to the replacement of the deciduous by the permanent dentition. The amount of decrease was more variable but generally greater in females than in males, but in both sexes arch length remained constant after 14 years of age.

Intercanine width was investigated by Barrow and White,[8] Moorrees,[7] and Sillman,[9] all observing that there was a rapid increase from 6 to 9 years of age, corresponding with permanent incisor and canine eruption. From 10 to 12 years there was a decrease in intercanine width, which then remained stable according to Moorrees but continued to decrease according to the other authors. Females were noticed to have smaller increases than males, although they were of greater velocity and of shorter duration.

Brown and Daugaard-Jensen[10] analyzed changes in arch length of subjects during adolescence and early adulthood. They found arch length decreases with increasing age. Moorrees and associates[11, 12] stated that decreases in arch length commence at age 3, after completion of the eruption of the primary dentition, with the decreases being greater in the mandible. He suggested that decreasing incisor-canine circumference noted from 13 to 18 years is associated with a decrease in arch length rather than a narrowing in arch width. Similar observations were made by DeKock,[13] who quantified the reduction as being in the order of 10 percent.

The incidence of incisor crowding was found by Barrow and White[8] in a longitudinal study to be virtually zero in the maxilla at age 6 years, and to have increased to 24 percent by age 14. In the mandible there was a 14 percent incidence of crowding at age 6, and 51 percent at 14 years of age. Cryer[14] stated a figure of 62 percent for the incidence of incisor crowding in a sample of 1000 school children aged 14 years. Sixty percent of the children who had crowding at age 14 had shown an increase in the severity of the crowding since age 11.

Foster and associates[15] showed a different pattern in their cross-sectional study of dental arch crowding in four age groups. For the mandible, at age 3 years, they found generalized spacing but by 7 years of age they found a 70 percent incidence of mandibular crowding. This value increased to 90 percent by age 14, and then decreased somewhat by age 25. They also noted that females tended to have more crowding than males in all age groups despite the greater average size of the male dentition.

Moorrees[7] observed a somewhat different pattern. He suggested that there was considerable crowding in the 8 to 10 year age period, corresponding to the eruption of the permanent canines, but that this decreased between the ages of 12 to 14 years and then increased again from 14 to 18 years of age. In untreated individuals attempts to correlate incisor crowding with other dental and skeletal features have been somewhat limited due to difficulties in quantifying incisor crowding and due to the apparent multifactorial etiology of malalignment. Nevertheless, growth has been implicated by some authors as a primary factory, Bjork and Skieller[16] suggesting that incisor position may be correlated to the amount and direction of facial growth. Lundstrom[17] studied changes in crowding and spacing of teeth with age and found a significant correlation between increases in incisor crowding with age and decreases in arch length.

Carmen[18] conducted a serial study of mandibular anterior crowding in untreated cases at ages 12 and 18 and its predictability. The study quantified model data in detail but had a limited cephalometric analysis. It was found that there was no significant relationship between incisor crowding and gender or Angle classification. Arch length, canine width, and molar width changes were found to be insignificant factors in controlling crowding but may have contributed in small measure to a multifactorial relationship associated with crowding. Incisor irregularity of the whole sample tended to increase with time, but nearly a third of the cases actually showed improvement in incisor alignment. Thus it was concluded that no single variable measured at either observation time, or the change in any single variable between observations, correlated significantly with crowding changes.

MATERIALS AND METHODS

The material used in this study was selected from the records of children included in the Burlington Growth Center Study, Ontario, Canada. The sample was limited to individuals with dental and skeletal Angle class I relationships who had undergone no orthodontic treatment of any sort. Sixty-five cases, with complete records in the mixed dentition, early permanent dentition, and in early adulthood were collected (Table I). All the cases selected were judged to have a clinically "good" occlusion and therefore represented

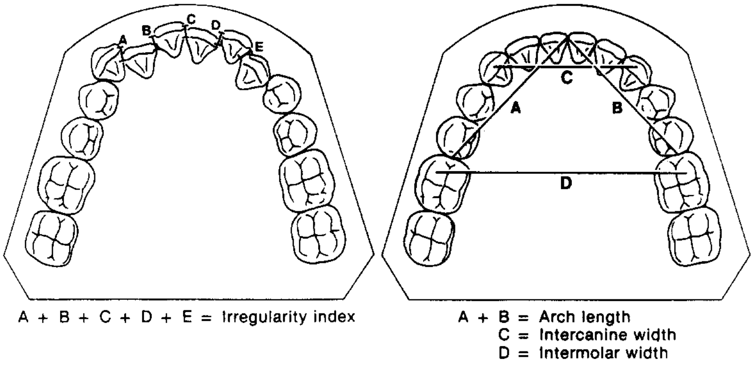

Fig. 1. Measurement technique.

Table I. Sample characteristics

		N	*Median (yr.)*	*Range (yr.)*
Mixed dentition (T_1)	Male	33	9.05	7.97-9.93
	Female	32	9.10	6.18-10.30
	Pooled	65	9.06	6.18-10.30
Early permanent dentition (T_2)	Male	33	13.20	11.93-14.32
	Female	32	13.04	10.27-14.46
	Pooled	65	13.06	10.27-14.46
Early adulthood (T_3)	Male	33	20.07	18.05-21.09
	Female	32	20.06	17.98-21.83
	Pooled	65	20.06	17.98-21.83

orthodontic "normals" rather than orthodontic "ideals." Sample selection was initially based on the presence of good quality longitudinal records, with no malformed or congenitally absent teeth and with all the points to be measured clearly identifiable.

Time 1 (T_1). Mixed-dentition stage. The mandibular permanent incisors and first molars as well as second deciduous molars were present. In addition, either deciduous canines or permanent canines plus deciduous first molars were in place. This state of development was taken to represent the mid-mixed dentition and would closely correspond to the time when early orthodontic therapy might be initiated in cases with severe malocclusions.

Time 2 (T_2). Early permanent-dentition stage. Selection was based on the completion of eruption of the permanent dentition (apart from third molars), with all the mandibular teeth present in the mouth and having their marginal ridges and entire occlusal surfaces visible. This stage of development was taken to represent the early permanent dentition and would closely correspond to the time when full conventional orthodontic therapy might be initiated.

Time 3 (T_3). Adult-dentition stage. To qualify for inclusion in the study, males were at least 18 years of age and females at least 17 years of age. These criteria were selected in an attempt to minimize the effects of any remaining skeletal growth.

With dial calipers the following measurements were obtained by one observer to the nearest tenth of a millimeter for each set of casts (Fig. 1):

Irregularity index—As suggested by Little,[19] the summed displacement of the anatomic contact points of the lower anterior teeth.

Mandibular intercanine width—The distance between cusp tips or estimated cusp tips in cases of wear facets.

Mandibular intermolar width—The distance between mesiobuccal cusp tips or estimated cusp tips in cases of wear facets.

Mandibular arch periphery/arch length—As suggested by Nance,[20] the "inside arch length" measured as the sum of the right and left distances from mesial anatomic contact points of the first permanent molars to the contact point of the central incisors or to the midpoint between the central incisors if spaced.

Overbite—Mean overlap of upper to lower central incisors.

Overjet—The distance parallel to the occlusal plane from the incisal edges of the most labial maxillary to the most labial mandibular central incisor.

Measurement error was evaluated by randomly selecting 15 casts, each measured twice on two separate occasions. The within-day and between-day standard deviations were found to be in the 0.06 to 0.18 mm. range with the exceptions of overjet and overbite, which were in the 0.32 to 0.57 mm. range. The coefficients of variability were small in relation to the overall variability of the sample.

Statistical analysis was performed by standard methods. Groups were compared by Student's t test for independent groups, and the significance of changes across time was determined by the Student's t test for paired data and the Scheff's test. Association between variables was evaluated by the Pearson product-moment correlation coefficient, discriminant analysis, and a multiple linear regression analysis. Statistical sig-

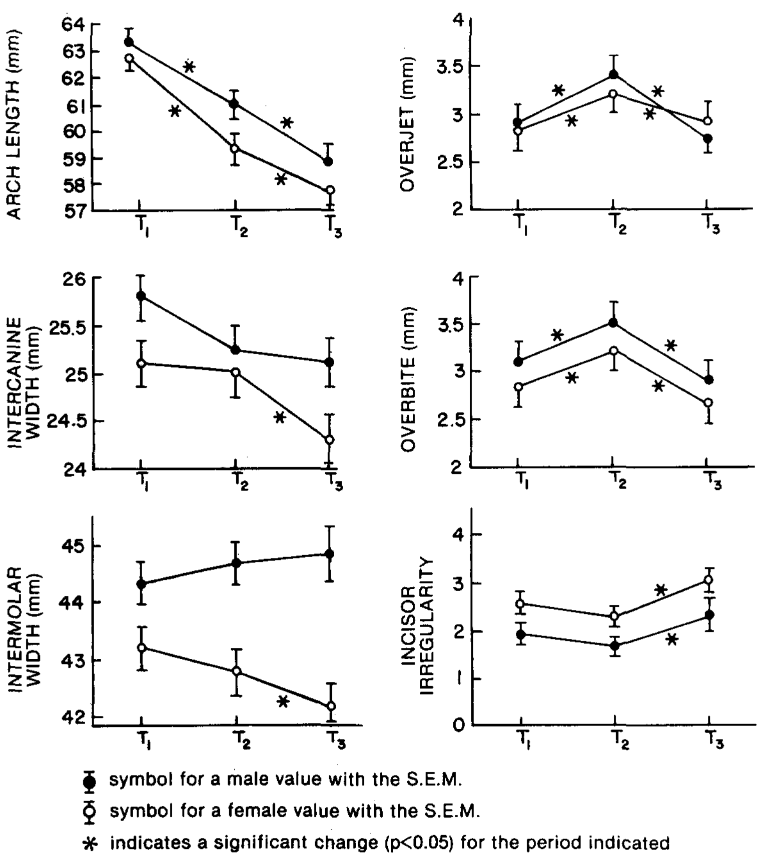

Fig. 2. Changes in dental variables.

Table II. Pooled cast measurements

	T_1			T_2			T_3		
	Mean	*S.D.*	*S.E.*	*Mean*	*S.D.*	*S.E.*	*Mean*	*S.D.*	*S.E.*
Arch length (mm.)	63.12	2.98	0.37	60.24*	3.41	0.42	58.29*	3.15	0.42
Intercanine width (mm.)	25.45	1.47	0.18	25.14	1.43	0.18	24.70*	1.53	0.19
Intermolar width (mm.)	43.74	2.40	0.30	43.69	2.77	0.34	43.59	3.16	0.39
Overjet (mm.)	2.87	1.00	0.12	3.31*	1.21	0.15	2.82*	1.10	0.14
Overbite (mm.)	2.95	1.20	0.15	3.35*	1.00	0.12	2.76*	1.20	0.15
Incisor irregularity	2.22	1.23	0.15	2.00	1.17	0.14	2.70*	1.64	0.20

*Indicates a statistically significant difference ($p < 0.05$) from the previous measurement.

nificance was established at $p \leq 0.05$, and a correlation of $r > 0.7$ was considered of clinical importance.

RESULTS

Arch length/arch periphery

As illustrated in Fig. 2, both males and females demonstrated significant ($p < 0.001$) decreases in arch length over the two time periods. From pooled data (Table II), substantial loss of arch length was noted by early adulthood ($\overline{X} = -4.83 \pm 1.85$ mm.); more change occurred in the female group during the T_1 to T_2 interval while the male arch length declined at a constant rate (Table III). Sixty-one out of 65 cases showed decreases in arch length over the whole T_1 to T_3 period (Fig. 3A).

Intercanine width

Both sexes showed statistically significant ($p < 0.01$) decreases of intercanine width from the mixed-dentition stage into early adulthood ($\overline{X} = -0.75 \pm 1.45$ mm.). Constriction of the male group was gradual over the entire period while the females had the major

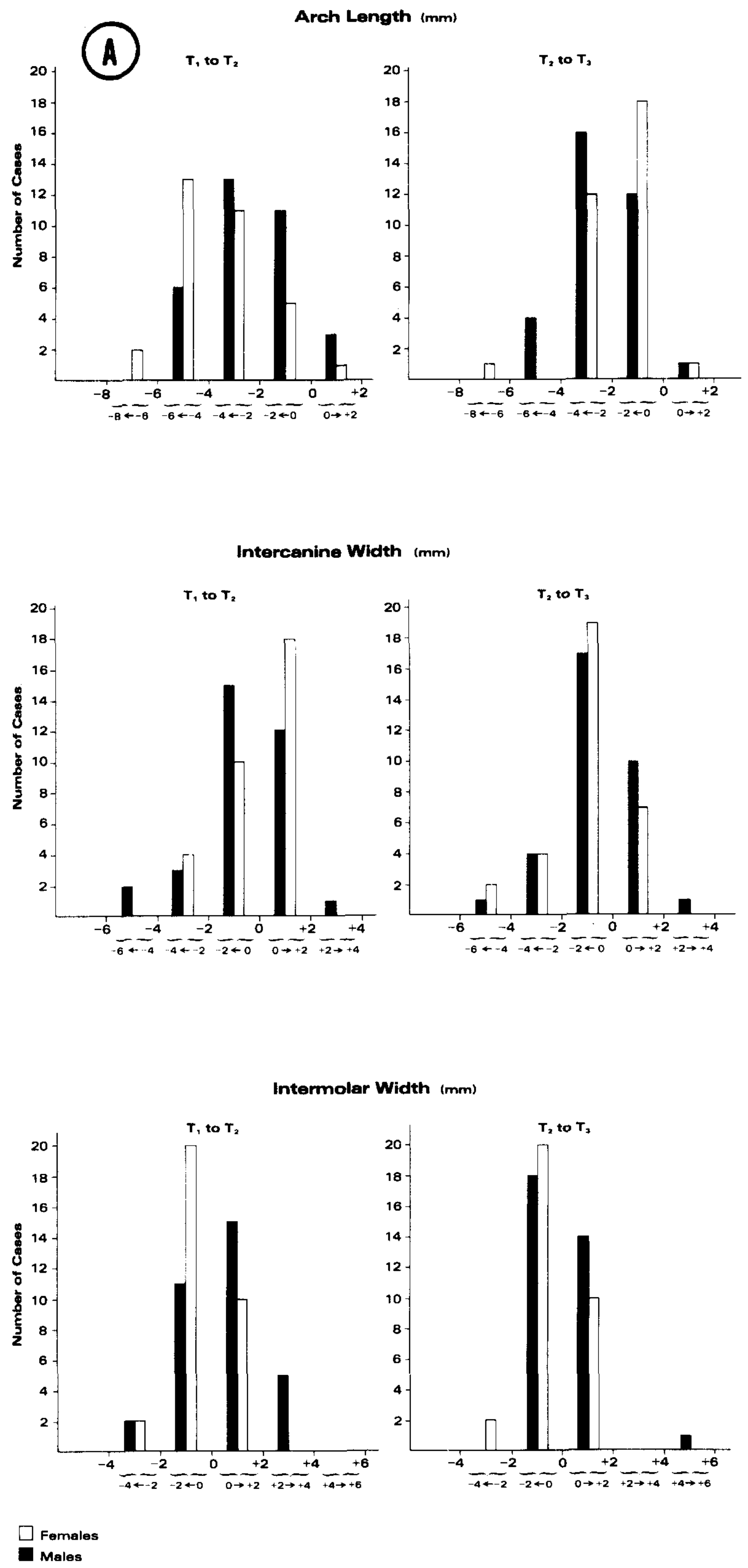

Fig. 3A. Frequency distribution of dental cast changes in arch length, intercanine width, and intermolar width.

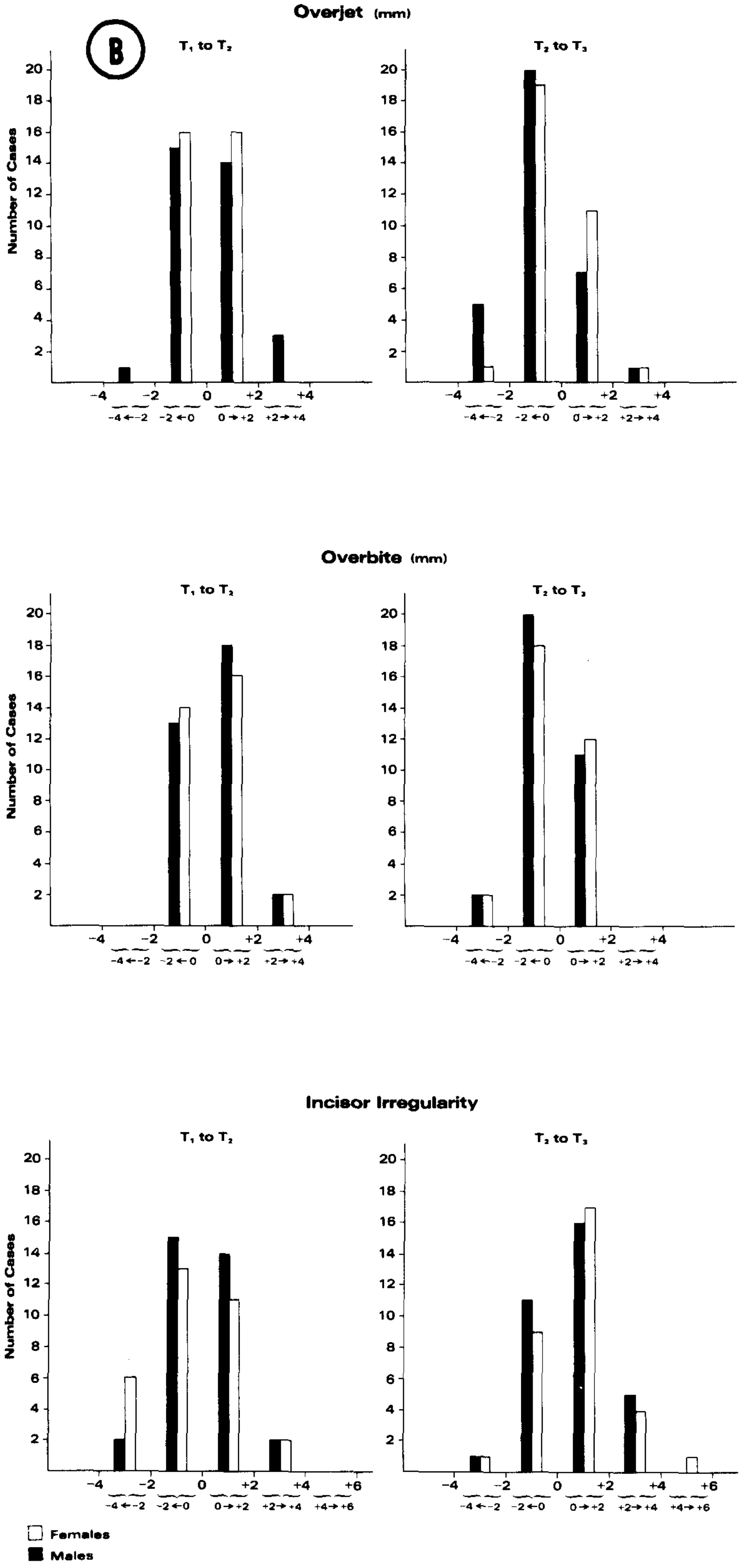

Fig. 3B. Frequency distribution of dental cast changes in overjet, overbite, and incisor irregularity.

Table III. Male and female cast measurement changes

		T_1 to T_2			T_2 to T_3		
		Mean	*S.D.*	*S.E.*	*Mean*	*S.D.*	*S.E.*
Arch length (mm.)	Female	−3.54*	1.65	0.29	−1.68*	1.44	0.25
	Male	−2.22*	1.74	0.30	−2.21*	1.46	0.25
	Female − Male	−1.32†	2.38	0.42	0.53	2.03	0.36
Intercanine width (mm.)	Female	−0.08	1.34	0.24	−0.73*	0.78	0.14
	Male	−0.52	1.67	0.29	−0.16	0.96	0.17
	Female − Male	0.44	2.09	0.37	−0.57†	1.19	0.21
Intermolar width (mm.)	Female	−0.41	1.32	0.23	−0.47*	0.86	0.15
	Male	+0.30	1.14	0.20	+0.25	1.44	0.25
	Female − Male	−0.71†	1.75	0.31	−0.72†	1.70	0.30
Overjet (mm.)	Female	+0.34*	0.79	0.14	−0.28*	0.72	0.13
	Male	+0.53*	1.02	0.18	−0.68*	0.98	0.17
	Female − Male	−0.19	1.24	0.22	0.40	1.19	0.21
Overbite (mm.)	Female	+0.40*	1.02	0.18	−0.56*	0.62	0.11
	Male	+0.45*	1.09	0.19	−0.63*	1.15	0.20
	Female − Male	−0.05	1.47	0.26	0.07	1.30	0.23
Incisor irregularity	Female	−0.32	1.31	0.23	+0.85*	1.06	0.19
	Male	−0.15	1.18	0.21	+0.55*	0.94	0.16
	Female − Male	−0.17	1.75	0.31	0.30	1.42	0.25

*Indicates a statistically significant change ($p < 0.05$) for the time period concerned.
†Indicates a statistically significant difference between the changes seen in males as against females ($p < 0.05$).

Table IV. Mean annual changes

	Sample of untreated class I	*Sample of treated class I*	*Significance difference between samples*
Arch length (mm.)	−0.28	−0.29	N.S.
Intercanine width (mm.)	−0.06	−0.19	$p < 0.05$
Overjet (mm.)	−0.07	+0.07	$p < 0.05$
Overbite (mm.)	−0.08	+0.07	$p < 0.05$
Incisor irregularity	+0.10	+0.21	$p < 0.05$

change during the permanent-dentition stage. From T_2 to T_3, 48 out of 65 cases showed decreases in intercanine width (Fig. 3A).

Intermolar width

Statistically significant differences ($p < 0.05$) in intermolar width were seen for males and females throughout the entire T_1 to T_3 period. Males showed small, insignificant increases in intermolar width over the whole T_1 to T_3 period while females showed a statistically significant loss in intermolar width ($\bar{X} = -0.88 \pm 1.53$ mm.), the majority of the decrease occurring over the T_2 to T_3 period where 22 out of 32 cases showed decreases (Fig. 3A).

Overjet

When compared to the T_1 value, the T_3 overjet showed no statistically significant increase. This, however, masks a modest but statistically significant increase in overjet from T_1 to T_2 ($\bar{X} = 0.44 \pm 0.89$ mm., $p < 0.001$), which was followed by a very similar decrease from T_2 to T_3 ($\bar{X} = -0.48 \pm 0.89$ mm., $p < 0.001$). Statistically, the male and female changes were not significantly different (Fig. 3B).

Overbite

Overbite increased during the transition from the mixed dentition to the permanent dentition ($\bar{X} = 0.40 \pm 1.04$ mm., $p < 0.01$), with a subsequent reduction during the maturation of the permanent dentition from T_2 to T_3 ($\bar{X} = -0.59 \pm 0.89$ mm., $p < 0.001$). Changes were similar for males and females (Figs. 2 and 3B).

Incisor irregularity

Although there was no statistically significant change in crowding during the mixed-dentition stage, both males and females demonstrated a statistically significant ($p < 0.001$) increase of incisor irregularity during the permanent-dentition interval. Statistically, females showed significantly ($p < 0.05$) greater crowding than males at T_1 (2.59 ± 1.41 mm. vs. 1.87 ± 0.98) and at T_3 (3.13 ± 1.75 mm. vs. 2.28 ± 1.44). Twenty-two females and 21 males showed increases in incisor irregularity from T_2 to T_3 (Fig. 3B).

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Attempts to find associations between pairs of the dental parameters proved unsuccessful. None of the correlation coefficients approached clinical significance, suggesting that the changes seen in the dental cast parameters were all relatively independent. The multiple regression analysis test failed to reveal any clinically significant linear combinations of parameters that could be used to predict future changes in any of the dental cast variables.

A discriminant analysis test was carried out on the parameters arch length and incisor irregularity for the T_2 to T_3 period. The objective was to determine whether subjects that had clinically significant loss of arch length (arbitrarily set at more than 3.0 mm.) or a clinically significant incisor irregularity index (arbitrarily set at greater than 3.5 mm.) at T_3 were significantly different in other respects from the rest of the sample. It was found that the subjects with decreases in arch length or increases in incisor irregularity greater than the limits stated could not be differentiated in any other respect from the rest of the sample, thus implying that it was not possible to determine which cases would suffer significant decreases in arch length or increases in incisor irregularity by examining the rest of their characteristics.

In order to provide a clinical perspective, the untreated sample of the present study was compared to a treated class I group from the sample studied by Little and associates.[5] Both samples were examined by the same observer using the same methodology. The treated group underwent first premolar extraction at a mean age of 13 years with routine comprehensive edgewise mechanotherapy and retention. Records were assessed at pretreatment, end of active treatment, and at least 10 years after discontinuation of all forms of retention. The two groups were not identical with regard to sample size (treated $N = 30$, untreated $N = 65$), the mean period of observation T_2 to T_3 (treated 12 years, 7 months; untreated 7 years, 0 months), and mean age at the final sampling time (treated age T_3 30 years, 1 month; untreated 20 years, 1 month). Due to the differences in both the length of the T_2 to T_3 periods and the mean age at T_3, comparisons between the two studies must be cautious. It was believed that a comparison of the mean annual changes over this period would be the most appropriate parameter to indicate the progress of the maturation process (Table IV).

Arch length mean annual decrease was virtually identical for the two groups but all other measures showed significant differences ($p < 0.05$). Although both groups showed a tendency for intercanine width to decrease, the rate of decrease was three times as fast for the treated group. Although the difference between samples in overbite and overjet were statistically but probably not clinically significant, it was interesting to note that the treated cases showed an increase in these measures while the untreated group had decreases. Incisor irregularity increased twice as fast in the treated group as in the untreated sample.

DISCUSSION

Review of the findings of the present study in light of the original research questions posed showed highly complex, variable, and in many cases unquantifiable interrelationships of factors involved in the maturation of the normal dentition.

One of the most closely examined changes was that of arch length (periphery). In cases treated 10 years after retention, Shapiro[2] and Little and associates[5] have demonstrated that treated cases usually decrease in arch length after treatment. This feature was also noted in the present study, with the changes occurring both during the transition from the mixed to the permanent dentition and later. Changes in the untreated sample were similar to those seen in untreated groups by DeKock[13] and by Brown and Daugaard-Jensen.[10] The fact that the annual rate of decrease in arch length in the untreated sample was very similar to that seen in the treated 10-year postretention cases might be taken to imply that similar maturation processes are at work as far as arch length is concerned.

Intercanine width and its immutability have long been the subject for heated discussions in the orthodontic literature.[21-23] Postretention studies of treated cases have typically shown marked reductions in intercanine width.[2,5] In many cases, the intercanine dimension reduced beyond the original value, whereas in a few cases, some net gain after expansion was noted. In untreated individuals, decreases in intercanine width after the eruption of the permanent teeth have been documented, these changes possibly continuing into the permanent dentition.[8,9] The present study showed intercanine width to be a very stable dimension in males, with only minor decreases being noted in females from 13 to 20 years. The extent of this change was very similar to that found in a postretention study by Gardner and Chaconas,[4] who showed less than 1 mm. long-term reduction of intercanine width representing only half the average change noted by Shapiro[2] and Little and associates.[5]

In comparison with other studies of untreated individuals, the results of this study tend to support the suggestion of Moorrees and Chadha[11] that intercanine width remains virtually unchanged after the eruption of the permanent dentition. Conversely, Barrow and White[8] and Sillman[9] contend that intercanine width continues to decrease during the maturation of the permanent dentition. If we could assume stability of intercanine width, then the clinical implication would be to confirm the precept of Strang[23] that intercanine width is a "very stable dimension and should remain inviolate during treatment." Why Little's group[5] showed a significantly faster rate of decrease in intercanine width than did the untreated group of this study remains unexplained. Many of this sample were not expanded during treatment but then showed considerable postretention constriction. It is possible that untreated cases will show continuing loss of width with time and may very well approach the state noted in Little's sample by the fourth and fifth decade of life.

Intermolar width has commonly been used as a measure of posterior arch dimension. Longitudinal studies of untreated cases[7, 10] have shown slight increases in intermolar width with increasing age, whereas in postretention studies of treated cases, a distinct difference was noted between the results of extraction and nonextraction therapy.[2] In the extraction group intermolar width decreased during treatment and continued to decrease after retention. In the nonextraction group there was a maintenance, and in a few cases some increase, in the intermolar width. The results of the present study closely approximate the findings of the nonextraction postretention group in that intermolar width, in general, remained very stable.

Several longitudinal studies[7, 8, 24] of untreated cases have shown specific trends in the changes noted for overjet and overbite, these being supported by the results of the present study. From 9 to 13 years, during the period of transition from the mixed to the permanent dentition, the overjet and overbite were seen to increase significantly, whereas from 13 to 20 years, during the maturation of the permanent dentition, these changes were reversed and decreases in overjet and overbite were noticed. These changes were in contrast to the postretention increases noted in treated cases; however, the changes in all cases were relatively small. It was interesting to note that in a few cases the 10-year postretention values of the treated cases were very similar to the pretreatment values, suggesting a tendency to return to the original pattern of malocclusion.

A similar association between the values for the mixed dentition (T_1) and mature permanent dentition (T_3) was also noted in the present study. From these results it would seem that in the untreated individual the greatest overjet and overbite are often seen in early adolescence, which is the period when orthodontic therapy is typically initiated.

Increases in lower incisor crowding during the maturation of the untreated dentition have been reported by several authors.[14, 17, 18] The nature of the changes reported tended to vary, with Foster and associates[15] reporting the peak of crowding occurring at 14 years with a subsequent decrease. Moorrees and Chadha[11] observed a decrease in crowding from the mixed dentition (8 to 10 years) until the eruption of the permanent dentition (12 to 14 years) and then a subsequent increase up to age 18 years. The findings of this study closely parallel those of Moorrees in that there were minimal decreases in crowding from 9 to 13 years, followed by a small but statistically significant increase from 13 to 20. Similar to the results of Foster and associates,[15] incisor crowding was found to be greater in females, especially in the older age group. When compared to those in studies examining postretention lower incisor crowding in treated cases,[2, 5] the postretention irregularity indices were noted to be considerably higher in the treated cases ($\bar{X} = 3.5$ to 4.8) in the untreated normal group ($\bar{X} = 2.7$). In addition, the rate of increase of incisor crowding in the treated postretention group was approximately twice as fast as in the untreated normal group. These differences might be interpreted as suggesting that although the nature of the changes (increases in crowding) are similar, the extent of these changes is different in the treated as against the untreated groups. In other words, although both groups are moving in a similar direction they appear to be on different "tracks" with regard to the extent of the changes they manifest. This conclusion must be tempered by noting that the average age of the treated cases was 10 years greater than the untreated sample. Perhaps, with time, the untreated sample will also crowd to a similar extent.

Some might argue that the changes seen in the postretention samples were due to the type of mechanotherapy used. The presentation of results from similar long-term studies where different mechanics were used may help to resolve this debate. Further considerations include the possibility that the 10-year postretention and the untreated normal samples may not be representative of the same population. Serial examination of a "random" untreated sample as well as untreated malocclusions may clarify the issue.

Several authors[17, 24–26] have suggested that the amount and direction of facial growth may be at least partially responsible for the maturational changes seen in the dentition and, in particular, the position of the lower incisors. This question will be addressed in a future paper that will consider the relationships between dental and skeletal changes during maturation in untreated normals.

SUMMARY

On the basis of diagnostic cast records of 65 untreated normal individuals examined in the mixed-dentition stage, early permanent-dentition stage, and early adulthood, the following conclusions were reached:

1. There was a consistent trend towards a decrease in arch length from the mixed dentition into early adulthood.

2. There were small decreases in intercanine width, with the most significant change occurring in females from 13 to 20.

3. Intermolar width in general remained very stable with some degree of sexual dimorphism present. Males showed insignificant increases while the females showed a small but significant decrease from 13 to 20 years.

4. Overjet and overbite typically increased from 9 to 13 years, then decreased from 13 to 20 years, resulting in minimal overall changes.

5. Incisor irregularity increased from 13 to 20 years, female exhibiting more incisor irregularity than males at the adult stage.

6. Changes in individual dental variables could not be correlated to other parameters measured. No associations or predictors of clinical value were found.

7. Maturational changes in the permanent dentition of a sample of untreated normals appeared, in general, to be similar in nature, but significantly less in extent, than changes in similar parameters examined in a postretention sample of treated cases.

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