Changes in Mandibular Interdental Distance Concurrent with Rapid Maxillary Expansion

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Rapid expansion of the midpalatal suture has been used for more than a century as a treatment for maxillary constriction. Although there is an abundance of material on this subject in the dental literature, virtually all of it pertains to reactions within the maxillary complex. Very little is written about the response of the mandible, or of the mandibular teeth, to upper arch expansion.

The purpose of this investigation is to study the changes in mandibular interdental distance, if any, concurrent with rapid expansion of the midpalatal suture. An attempt will be made to recognize the changes that would have occurred during the course of normal dental development and to identify those changes that are the result of the maxillary expansion alone. The effects of the original buccolingual tooth relationship on the extent of the changes in mandibular interdental distance will also be evaluated.

Review of Literature

The earliest references to palatal expansion procedures were made in 1860 by White[11] and by Angell.[1] For the next fifty years the literature reveals considerable controversy over the possibility and desirability of such a procedure with Hawley[6] and Ketcham,[7] among others, claiming that the midpalatal suture could not be opened.

Interest in rapid palatal expansion decreased in this country following Angle's[2] proposal in 1907 that the full complement of teeth could be arranged by expansion into ideal arch forms producing a good functional occlusion. His concepts further held that, if the teeth were gently moved into their proper relations by conservative orthodontic means, and if vigorous function followed, bone would grow to support them.

In spite of frequent failures to obtain these objectives, the functional concept of development remained popular for the next quarter century. Finally, in 1938 Brodie[3] and associates presented evidence through cephalometric analysis which demonstrated that actual bone changes accompanying orthodontic treatment were restricted to the alveolar processes. These findings provoked renewed interest in expansion of the basal maxillary segments by the rapid expansion technique.

In 1959, in a rapid expansion technique conducted on pigs, Haas[4] reported, among other findings, that the mandibular dental arch expanded in response to altered functional forces resulting from maxillary expansion. He later reported the results of a clinical study of midpalatal expansion in ten patients ranging from nine to eighteen years of age.[5] He found that mandibular intermolar distance increased from 0.5 to 2.0 mm in all cases, while mandibular intercanine distance remained the same in five cases, increased from 0.5 to 1.5 mm in four cases, and decreased 0.5 mm in one case. He postulated that "the forces of occlusion were altered by the expansion so that the normal lingual vector of force on the mandibular buccal teeth was lost and the lateral movement of the maxillae widened the area of attachment of the buccal musculature. This resulted in a change of balance between the tongue and buccal musculature."

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In 1970 Wertz[9] reported that, as the result of a study of rapid palatal expansion in forty-eight patients, "the lower arch width as measured across the first permanent molars failed to change in thirty-five, gained in twelve, and narrowed 1.0 mm in one case. Of the gains, two gained 2.0 mm, two gained 1.5 mm, five gained 1.0 mm, and three gained 0.5 mm." He concluded that "although the majority of cases failed to demonstrate lower arch width gain, a longer study might be expected to disclose such a gain, as function of the overexpanded maxillary buccal segments would tend to upright the mandibular antagonists."

Materials and Method

This study involved thirty-eight patients from two private orthodontic practices.* The sample included twenty-seven females ranging in age from six to fourteen years, and eleven males ranging in age from four to thirteen years. The average age of the entire sample was just over ten and one-half years. Complete orthodontic records were obtained on each patient prior to treatment, and dental casts were again obtained following expansion and stabilization. The average length of time between records was seven months.

Each patient was treated with a tissue-borne, fixed, split-acrylic expansion appliance with jackscrew. Construction of the appliance was as described by Haas,[5] except that buccal stabilization bars were not used in every instance. The expansion appliance was cemented to the upper first permanent molars and either the first premolars or the first deciduous molars. In two instances upper second deciduous molars were used, as first permanent molars had not erupted.

*The private practices of the author and of Dr. Arthur Ingram, Fremont, California.

Activation of the appliance was initiated with four one-quarter turns on the day of placement, with the patient or parent adding a one-quarter turn each morning and each evening of subsequent days. When maxillary expansion consistent with the requirements of the individual patient's orthodontic problem was obtained, the appliance was stabilized and allowed to remain in place for approximately three months to insure maximum retention of the gained expansion. At the completion of this three-month retention period, the expansion appliance was removed and the patient was allowed to "recover" for about ten to fourteen days at which time the postexpansion dental casts were made. The patient was either given a retainer, or the previously established orthodontic treatment plan was continued. The increases in maxillary intermolar distance ranged from 3.5 to 13.5 mm and averaged 5.8 mm.

All measurements were made from the dental casts utilizing a Boley gauge whose points had been sharpened to enable as discriminating use of the instrument as was possible. Measurements were recorded to the nearest 0.1 mm and were felt to be reproducible to plus or minus 0.1 mm. The changes in distance between upper canines, upper first permanent molars, lower canines, and lower first permanent molars were recorded. Wherever possible, the most prominent cusp tip was used to measure interdental distance, although it was occasionally more accurate to use pits or fissures on the molars. The landmark used for a particular tooth was selected to give the most accurate possible measurement of interdental change and was determined by morphology, or changes in morphology between records, such as worn cusps or filled-in fissures. The age of the patient at the completion of treatment, as well as the length of time between dental casts, was noted.

The preexpansion buccolingual intercanine and intermolar relationships were also noted for each patient and were categorized as follows: *Crossbite:* both lower canines (or molars) in crossbite, or the tooth on one side in crossbite and the tooth on the other side either out of occlusion or edge-to-edge. *Normal:* both lower canines (or molars) in normal buccolingual occlusion, or the tooth on one side normal and the tooth on the other side either out of occlusion or edge-to-edge. *Out of Occlusion:* neither lower canine (or molar) contacting an antagonist. *Edge-to Edge:* both lower canines (or molars) edge-to-edge buccolingually, or the tooth on one side edge-to-edge and the tooth on the other side out of occlusion, or the tooth on one side in crossbite and the tooth on the other side in normal occlusion.

Results

In 1959 Moorrees[8] published his longitudinal studies on the dental development of two groups of normal children. Of particular importance to the present author's study were the changes in distance, as a function of age and sex, between the mandibular canines and the mandibular first permanent molars. Although Moorrees' data are not precise, they do represent the best estimate available as to what could be expected to occur in the absence of any treatment.

The sex, midtreatment age, and length of time between dental casts were known for every patient in the author's study. Moorrees' data were used to estimate for each patient the changes in interdental distance that would have occurred even without maxillary expansion. These changes were subtracted from the observed data, thereby eliminating sex, age, and

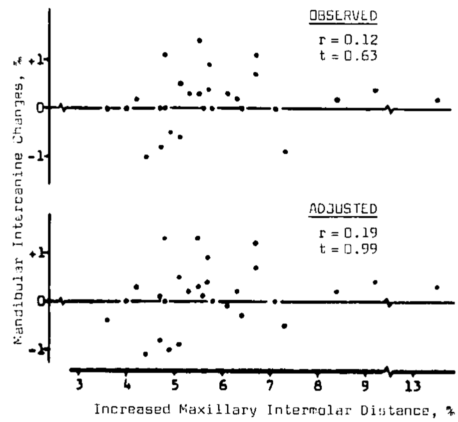

Fig. 1 Changes in distance between mandibular canines versus changes between maxillary first permanent molars. The "adjusted" data represent changes that are the result of maxillary expansion alone; t-tests show neither correlation coefficient (r) significantly different from zero at the 0.05 level.

treatment time as variables. The resulting "adjusted" data represent those changes in interdental distance that are the result of maxillary expansion alone.

Figure 1 is a plot of the change in mandibular intercanine distance as a function of the change in distance between maxillary first molars. The observed data are above, the adjusted data below. A similar plot for the change in mandibular intermolar distance is shown in Figure 2 with an equally poor correlation. Figure 3 represents the change in mandibular intercanine distance with the increase in maxillary intercanine distance, and again there is no correlation.

Table I shows the changes in mandibular intercanine distance and mandibular intermolar distance, independent of the amount of maxillary expansion, for both the observed data and the adjusted data. For comparison purposes, mandibular intercanine data from the 1961 Haas study and from a private communication with Wertz, and mandibular intermolar data from the 1970 Wertz study are included. The

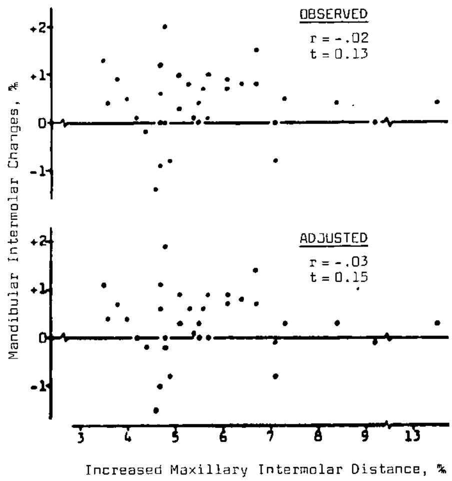

Fig. 2 Changes in distance between mandibular first permanent molars versus changes between maxillary first permanent molars. The "adjusted" data represent changes that are the result of maxillary expansion alone; t-tests show neither correlation coefficient (r) significantly different from zero at the 0.05 level.

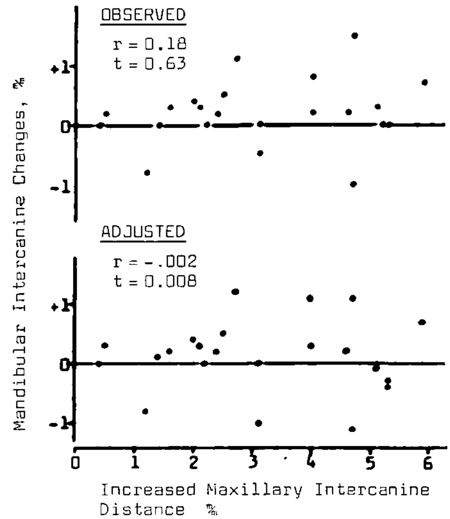

Fig. 3 Changes in distance between mandibular canines versus changes between maxillary canines. The "adjusted" data represent changes that are the result of maxillary expansion alone; t-tests show neither correlation coefficient (r) significantly different from zero at the 0.05 level.

TABLE I

Changes in mandibular interdental distance

	N	$\bar{X}$	S_x	$S_{\bar{x}}$	t
Mandibular Canines		mm	mm	mm	
Observed	30	0.22	0.62	0.11	1.97
Adjusted*	30	0.17	0.65	0.12	1.44
Wertz (Private Comm)	16	0.19	0.43	0.11	1.73
Haas (1961)**	10	0.25-0.45	0.54-0.76	0.17-0.24	1.46-1.87
Mandibular Molars					
Observed	34	0.39	0.71	0.12	3.23
Adjusted*	34	0.31	0.69	0.12	2.63
Wertz (1970)	48	0.26	0.58	0.08	3.09

N : number of observations in the sample,

$\bar{X}$: arithmetic mean of the sample,

S_x : estimated standard deviation of the population calculated from a single sample,

$S_{\bar{x}}$: estimated standard error of the mean,

t : significance ratio.

*The "adjusted" data represent changes that are the result of maxillary expansion alone. **Haas' data were not published sufficiently completely to allow other than the range in calculated values presented above.

For canines, t-tests show no mean to be significantly different from zero at the 0.05 level.

For molars, t-tests show means to be significantly different from zero at the 0.01, 0.05, and 0.01 levels, respectively.

Student's t-test indicates that none of the means of the changes in intercanine distance was significantly different from zero at the 0.05 level. The changes in intermolar distance, however, for both this study and for the Wertz study, were significantly different from zero at the 0.01 level, and the mean from this study remains significant at the 0.05 level after adjustment for normal development.

Figures 4 and 5 are histograms illustrating the frequency of distribution of changes in distance between mandibular canines and between mandibular first molars, respectively, for both the observed data and the adjusted data. The data are grouped in 0.5 mm increments in order to provide a significant number of observations at any one measurement. All four histograms show a definite pattern of normal distribution with the peak value slightly to the positive side of zero.

To investigate the effect of the preexpansion buccolingual interdental relationship on the amount of change in interdental distance, those patients with a particular preexpansion relationship (e.g., canines: crossbite) were considered to be a subsample and all remaining patients were considered to be a second, or complementary, subsample. The means of the two subsamples were calculated and then compared to test whether they were significantly different from each other. The results, presented in Table II, show that in no instance was the mean of a subsample significantly different from the mean of its complementary subsample at the 0.05 level. In other words, it would appear not to matter whether the teeth were initially in crossbite, normal occlusion, out of occlusion, or edge-to-edge. The amount of change in interdental width is independent of this relationship.

TABLE II

Effect of preexpansion buccolingual interdental relationship on changes in mandibular interdental distance (adjusted data)

	N	$\overline{X}$ mm	S_x mm	$S_{\overline{x}}$ mm
Mandibular Canines				
Crossbite	7	0.23	0.72	0.27
	23	0.15	0.64	0.13
Normal	7	0.26	0.65	0.24
	23	0.14	0.66	0.14
Out of occlusion	6	0.08	0.39	0.16
	24	0.19	0.70	0.14
Edge-to-edge	10	0.12	0.79	0.25
	20	0.20	0.58	0.13
Mandibular Molars				
Crossbite	4	0.30	0.33	0.16
	30	0.31	0.73	0.13
Normal	5	0.80	0.98	0.44
	29	0.23	0.61	0.11
Edge-to-edge	25	0.22	0.65	0.13
	9	0.58	0.77	0.26

t-tests show no subsample to have a mean significantly different from the mean of its complementary subsample, at the 0.05 level.

Summary and Conclusions

1. Thirty-eight patients treated with rapid expansion of the midpalatal suture by means of a fixed, tissue-borne, split-acrylic expansion appliance were examined. Among other records, plaster dental casts were taken prior to treatment and after expansion, and the changes in maxillary and mandibular intercanine and intermolar distances were recorded.

2. The 1959 work of Moorrees was utilized to estimate the changes in interdental distances that would have occurred even without treatment. The observed data were then "adjusted" to reflect those changes that were the result of the maxillary expansion alone.

3. There was no correlation between the change in mandibular intercanine distance or mandibular intermolar distance with respect to the increase in maxillary intermolar distance,

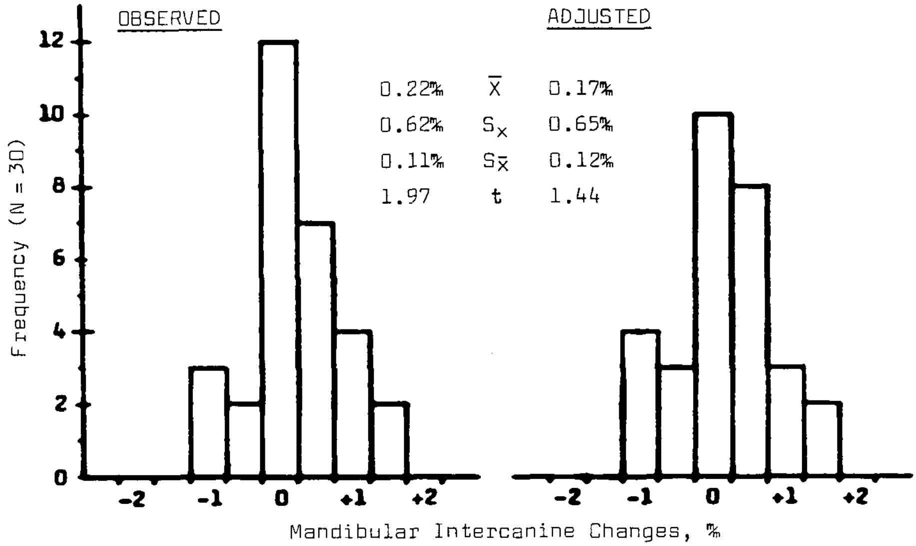

Fig. 4 Histogram illustrating frequency distribution of changes in distance between mandibular canines (0.5 mm grouping for clarity). For legend, see Table I. The "adjusted" data represent changes that are the result of maxillary expansion alone; t-tests show neither mean significantly different from zero at the 0.05 level.

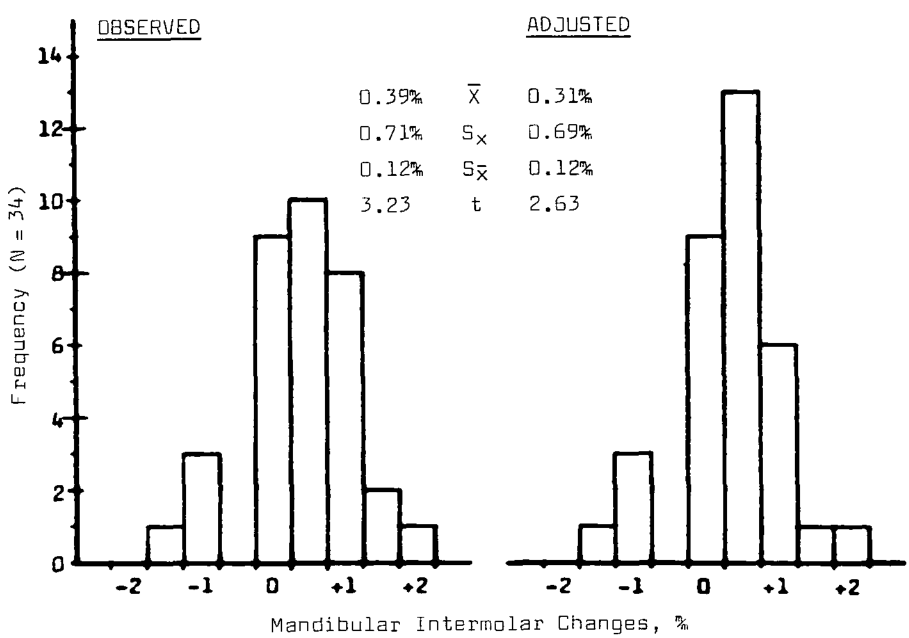

Fig. 5 Histogram illustrating frequency distribution of changes in distance between mandibular first permanent molars (0.5 mm grouping for clarity). For legend, see Table I. The "adjusted" data represent changes that are the result of maxillary expansion alone; t-tests show both means significantly different from zero at the 0.01 and 0.05 levels, respectively.

either in the data as observed or as adjusted.

4. There was also no relationship beween the change in mandibular intercanine distance with respect to the change in maxillary intercanine distance for either the observed or adjusted data.

5. The mean change in mandibular intercanine distance was observed as slightly greater than 0.2 mm, and as slightly less than 0.2 mm after adjustment. Neither mean was significantly different from zero at the 0.05 level.

6. The mean change in mandibular intermolar distance was observed as slightly less than 0.4 mm, and as slightly greater than 0.3 mm after adjustment. These means were significantly different from zero at the 0.01 and 0.05 levels, respectively.

7. The effect of the original buccolingual dental relationship between canines and molars had no significant effect upon the amount of interdental change experienced during maxillary expansion.

8. The fact that increased intercanine width was not significant while increased intermolar width was would seem to lend credence to the theory that lower arch expansion is as much the result of occlusal forces uprighting the teeth as it is to anything else.

9. The use of rapid maxillary expansion as a method of increasing lower arch length cannot be justified, at least in the short term. Unfortunately, it is difficult to evaluate the potential expansion in the long term, as these patients either go on with additional orthodontic treatment, or if no further treatment is instituted, they leave the practice and contact with them is lost.

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