A CEPHALOMETRIC ROENTGENOGRAPHIC STUDY OF CHANGES IN INCISOR ANGULATION ACCOMPANYING REMOVAL OF FULL BANDED ORTHODONTIC APPLIANCES

by

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I. INTRODUCTION

The movement of teeth incident to orthodontic treatment has long been a subject of interest to clinical orthodontists and researchers. Both microscopic and gross responses of the teeth and adjacent structures to treatment have been studied. Some of the effects of various phases of treatment have been demonstrated. By continued analysis of the changes accompanying orthodontic treatment more information may be gained concerning the effects of the appliances and how they may be used to the best advantage in clinical practice.

At the completion of active orthodontic treatment the positions of the teeth are controlled primarily by the orthodontic appliance. Upon removal of the appliance the band spaces between the teeth close, tooth contacts are established and the case begins to respond to functional stress. 1,2..

Changes in tooth position after appliance removal may occur quite rapidly. The adjustments of the dentition during this phase of treatment may or may not result in an improved interdigitation and angulation of the teeth.

In terminating active orthodontic treatment,

different procedures of appliance removal may be used. The desired result of all of these different procedures is to close effectively band spaces and maintain tooth position until retention appliances are placed.

It is difficult to determine accurately by direct observation tooth position changes which accompany appliance removal. Further, direct observation does not disclose whether differences in adjustments of the dentition are related to different procedures of appliance removal. Hence, a more accurate evaluation of this phase of orthodontic therapy is in order.

This study is an analysis of this single phase of treatment with a full banded appliance, and constitutes one area of investigation providing further information about the effects of orthodontic treatment.

The purposes of this paper are:

1. to determine from tracings of oriented lateral cephalometric radiograms of orthodontically treated cases, the angular changes of the maxillary and mandibular central incisor teeth accompanying removal of a full banded appliance.
2. to determine if angular differences can be detected cephalometrically among three different procedures of appliance removal.

II. REVIEW OF THE LITERATURE

Much has been written in the dental literature about dento-facial changes which occur during orthodontic treatment. These changes have been studied extensively through the use of cephalometric procedures. However, there are few reports of studies concerning the adjustments of the dentition during a specific phase of treatment, including that phase concerned with band removal and closure of the resultant interdental spaces.

Brodie et. al. (3) in 1938 were the first to employ cephalometric procedures in quantitating the results of orthodontic treatment. Although the purpose of the study was not specifically concerned with movements of the teeth as a result of treatment, it was observed that the teeth tended to return toward their original positions after treatment.

Downs (4) in 1940 reported a cephalometric study of fourteen cases and described changes occuring in the mandibular dentition during the initial stages of treatment. The cephalometric evaluation revealed that in all cases the lower incisor crowns moved labially. In 50

percent of the cases the incisor apices moved labially, and in 29 percent of the cases the incisor apices moved lingually. In 21 percent of the cases the incisor apices showed no change. In one case the incisors showed no tipping.

Margolis (5) in 1943, using cephalometric procedures, related the angulation of the mandibular incisors to the mandibular plane. He showed that the incisor-mandibular plane angle changed through treatment, after treatment and subsequent to retention in several of the cases reviewed.

Cole (6) in 1948, studied twenty-one extraction cases to determine the changes that took place in the positions of the mandibular incisor teeth, maxillary and mandibular molar teeth. Cephalograms were taken at the beginning of treatment, at the end of treatment, and when the cases had been out of retention for at least one year. He found that in over one-half of the cases studied, the axial inclination of the mandibular incisors increased subsequent to retention and that these teeth tended to return toward their original relationship with the mandibular plane after all retention had been removed. He stated that the increase in incisor procumbency seemed to be associated with forward positioning of the mandibular first molar, where-as in cases where the mandibular molar was more stable there was more stability of the incisors.

Litowitz (7) conducted a cephalometric study in 1948 on twenty non-extraction cases to determine the changes in position of the mandibular incisors, maxillary and mandibular molar teeth, that took place during treatment and one to five years after retention. His study indicated that in those cases where treatment had resulted in an increase in the axial inclination of the teeth, half tended to regain their former inclination and half became more procumbent. In the majority of cases where the treatment had resulted in a decrease in axial inclination, the angulation continued to decrease after retention.

Stackler (8) in 1958, conducted a clinical study of twenty extraction cases five years out of retention. He observed that spaces at the extraction site or those which open after appliance removal, tend to close by the buccal segments tipping into the extraction space. There was no evidence of increase of space at the extraction site during the five year interval. Deep overbites recurred in some of the cases, and the lower incisors tended to tip labially during this period of time.

Wallman (9) in 1958, studied cephalometrically thirty-seven patients treated by Dr. Tweed. Lateral cephalograms were made before treatment, after treatment, and at least one and a half to three years after all appliances were removed. He found a variety of ways in which the teeth change their positions after treatment. The

positions of the maxillary and mandibular central incisors and the mandibular first molars were found to be more variable after treatment than the maxillary first molars. There was also a tendency for the teeth to return toward their original inclinations and positions subsequent to treatment. There were a few exceptions in which the teeth continued in the directions initiated by treatment. It was observed that after treatment, the dentition moved forward a mean distance of 1.6 millimeters in 89.6 percent of the extraction cases. In addition, Wallman felt that the forward movement of the dentition showed no relationship to growth.

Vorhies (10) in 1960, studied ten orthodontic cases over a mean period of 31.8 days to quantitate tooth position changes produced by finishing orthodontic cases with rubber tooth positioners. He found that a tooth positioner does not establish a definite pattern in the selective depression or elevation of the teeth. Demonstrable quantitative changes may be accomplished with a tooth positioner in a short period of time. Improvement of the root torque of the anterior teeth is possible, but success in some cases may be an illusion and a result of other tooth movements. The axial changes of the anterior teeth were noted to be due primarily to tipping when tooth positioners were used.

In summary, a review of the literature reveals

that many cephalometric investigations have been conducted to determine the changes occurring in the dentition and surrounding structures during orthodontic treatment. Some studies included changes which occurred after all retention had been removed for varying periods of time. These studies indicate that the teeth have a strong tendency to assume a more procumbent position than they had occupied when the treatment was completed. Exceptions to this general tendency were noted, but no definite statements were made relative to the specific conditions under which the exceptions occur. One study reported the changes occurring in the dentition accompanying band removal and placement of a tooth positioner.

III. MATERIALS AND METHOD

A total of twenty-four orthodontic subjects, six males and eighteen females were included in the study. The subjects varied in age from twelve to twenty-four years. The subjects in Group I were being treated in the graduate orthodontic clinic at Western Reserve University School of Dentistry, those in Group II in a private practice, and those in Group III in another private practice. Table 1 summarizes the age, sex and dental characteristics of the sample.

Sample selection was based on the following criteria:

I. Active treatment procedures were accomplished with a full banded appliance.

II. Active orthodontic treatment was completed to the operator's satisfaction.

III. The subjects were ready to have the full banded appliance removed in preparation for orthodontic retention procedures.

Three different procedures of appliance removal were employed in the three groups of subjects studied. In Group I the cuspid and molar bands were left in place and closing arches were utilized to close band spaces. In Group II

all bands were removed at one appointment and a Kesling tooth positioner (11) placed at the same appointment. In Group III maxillary and mandibular anterior bands were kept in place after posterior bands were removed. Anterior sectional arch wires were placed. The lower anterior bands and sectional arch wires were removed four weeks later. Three weeks later, a mandibular retainer was placed and the remaining maxillary anterior portion of the appliance was removed. The maxillary retainer was placed approximately four weeks later. Table 2 summarizes the appliance removal procedures used for the three groups. (See Appendix).

Two lateral cephalometric roentgenograms were obtained for each subject in the three groups studied. The before film was obtained at the completion of active treatment while appliances were still in place. The after film was obtained at the completion of appliance removal and space closing procedures. The mean time interval between films of subjects in the three groups studied was 72.5 days. Table 3. (See Appendix).

Tracings of the before and after cephalometric records were made. All bilateral structures were traced as averages of right and left images. Figure 1 illustrates the anatomic structures and landmarks used in this study. Descriptions of anatomic structures and landmarks identified and traced are listed on pages 39 and 40 of the Appendix (12).

All contours and planes of orientation used in this study were established on the 'before' tracing of each subject. The contours and long axes of the maxillary and mandibular incisor teeth established on the 'before' tracing were transferred to the 'after' tracing by means of a template. The template included only the contours and long axis lines of the central incisor teeth. The template was oriented so that the labio-incisal contour and labial middle third of the root contour of the template and radiographic image on the 'after' radiograph were superimposed. The contours and long axes of the maxillary and mandibular teeth were then transferred to the 'after' tracing. Figure 2 illustrates the areas of the incisors used in orientation of the template on the 'after' cephalograms.

The mandibular plane established on the 'before' tracing was transferred to the 'after' tracing by maximum superimposition of mandibular contours of both tracings. (See Figure 2).

The palatal plane established on the 'before' tracing was transferred to the 'after' tracing by maximum superimposition of the palatal and cranial contours. (See Figure 3).

The following measurements were obtained from the tracings:

I. Measurement (A), the angular change of the mandibular

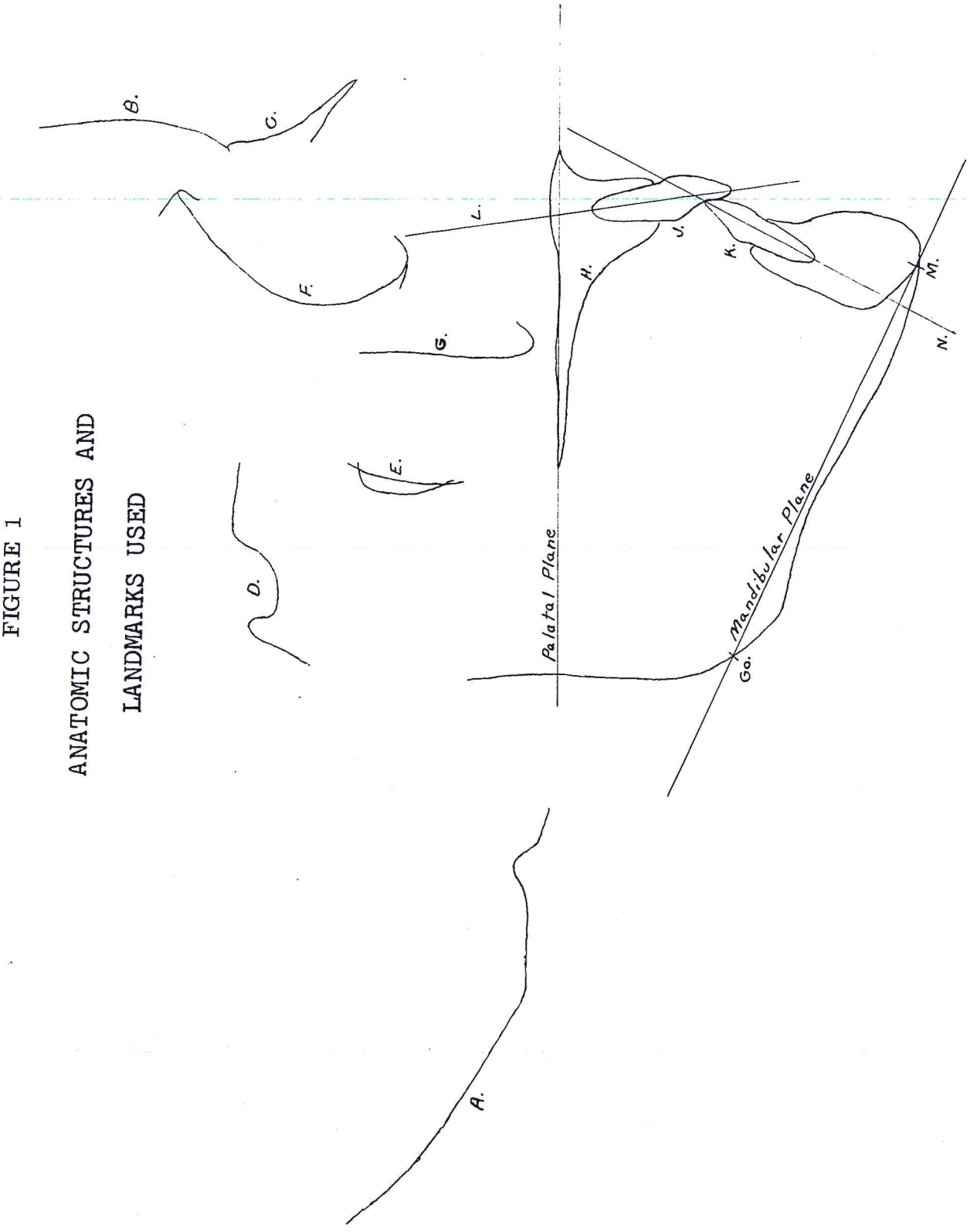
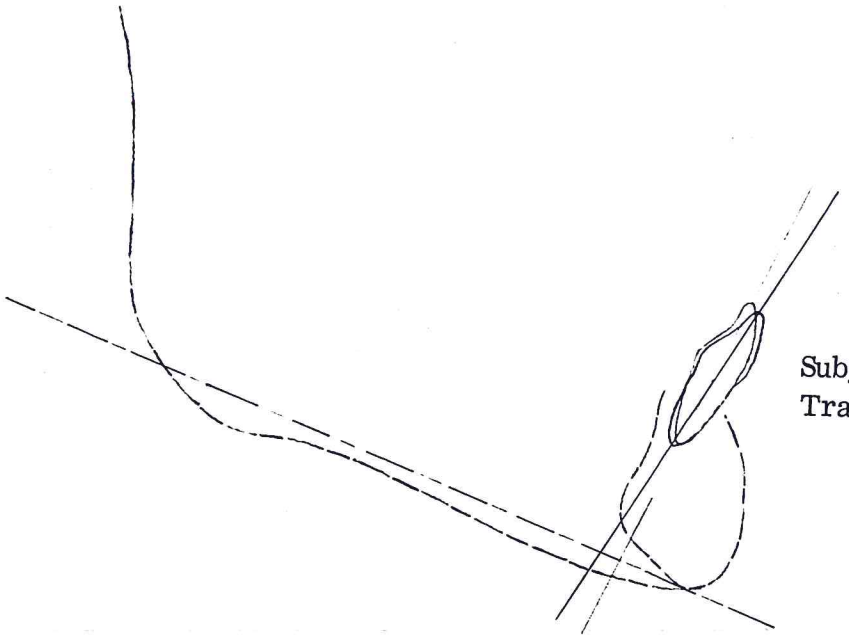


FIGURE 1

ANATOMIC STRUCTURES AND LANDMARKS USED

FIGURE 2

Red segments of the incisors indicate the areas used in orientation of the template on the 'after' radiograph



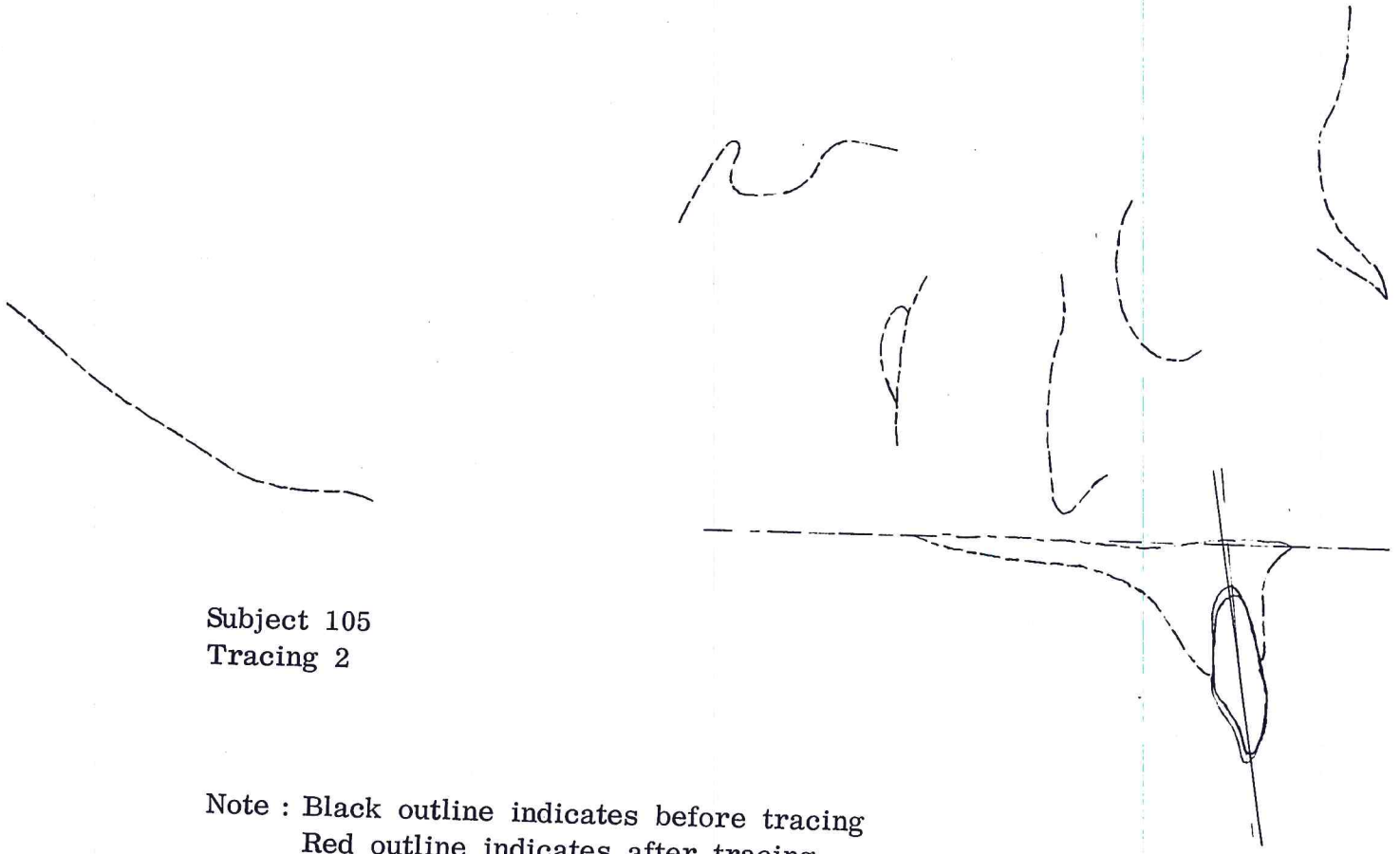
Subject 105
Tracing 2

Mandibular superimposition to transfer the mandibular plane from the before to the after tracing

Note : Black outline indicates before tracing
Red outline indicates after tracing

FIGURE 3

PALATAL AND CRANIAL SUPERIMPOSITION



Subject 105
Tracing 2

Note : Black outline indicates before tracing
Red outline indicates after tracing

central incisors in relation to the maxillary central incisors. (Figure 4).

II. Measurement (B), the angular change of the mandibular central incisors in relation to the mandibular plane. (Figure 4).

III. Measurement (C), the angular change of the maxillary central incisors in relation to the palatal plane. (Figure 4).

All measurements were made with a four inch plastic protractor and recorded to the nearest one-half degree.

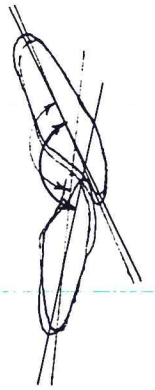
Three independent sets of tracings were made of all cephalometric records. Each set of tracings was made without reference to the previous set and after an interval of approximately two weeks. The measurements of central incisor angular change occurring during band removal procedures were recorded for the three determinations on each subject. Mean values obtained from three determinations of each subject's cephalograms for measurements A, B and C respectively, were accepted as the change in incisor angulation. Tables 4, 5 and 6.

The tracing error was determined by computing the variance among three determinations of a subject, and then pooling the variance of the individual determinations. (13). The tracing error was determined for measurements A, B and C separately. Tables 4, 5 and 6.

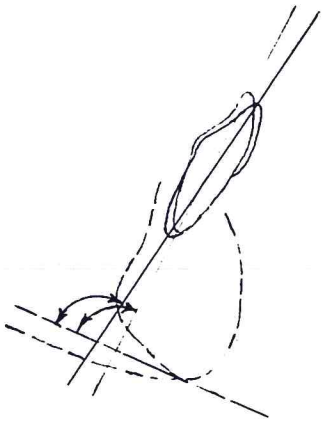
An analysis of variance was performed on measurements

FIGURE 4

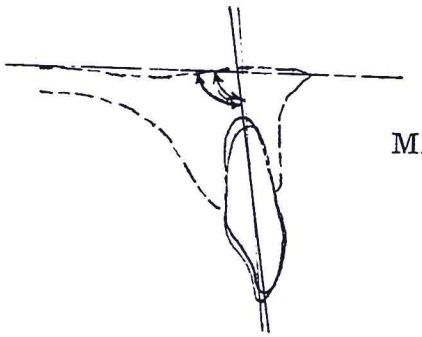
MEASUREMENTS A , B AND C



MEASUREMENT A



MEASUREMENT B



MEASUREMENT C

Note : Black indicates before record
Red indicates after record

A, B and C among the groups studied. Table 8 summarizes results of the analysis of variance for the three measurements. This statistical procedure is used to determine if the means of several groups differ significantly from each other. (13). Modifications in the analyses were made to compensate for samples of unequal size. Mean values calculated from three determinations were used in computing the analysis of variance for measurements A, B and C. A value of (F) greater than 3.47 is interpreted as evidence that the groups arose from populations having different means. (at the five percent level of significance) (13).

The data from all patients were pooled. The mean and standard deviations were calculated for measurements A, B and C respectively and are summarized in Table 10.

IV. FINDINGS AND DISCUSSION

The data on which this study was based are shown in Tables 4, 5 and 6.

Table 7 shows the means for measurements A, B and C for the three groups studied. It will be noted that there was a mean increase in Measurement A in all three groups. Measurements B and C showed a mean decrease in all three groups. (Figure 4).

Differences in measurements A, B and C between groups I, II and III were compared. No significant differences were found between the means of the three groups for measurements A, B or C respectively, at the five percent level of confidence. Table 8.

Data for measurements A, B and C respectively, of the three groups were pooled. A summary of the three measurements is presented in Table 10. The mean change of interincisal angulation, Measurement A, of the combined groups was +5.1 degrees with a range of -2.16 to +12.66 degrees. The standard deviation was 4.10 degrees, and the standard error was 0.125 degrees. The mean change in angulation of the mandibular incisor in relation to the mandibular plane, Measurement B, of the combined groups was -3.2 degrees with a range of +2.00 to -8.50 degrees. The

standard deviation was 2.72 degrees and the standard error 0.105 degrees. The mean change in angulation of the maxillary incisor in relation to the palatal plane, Measurement C, of the combined groups was -1.4 degrees with a range of +3.33 to -6.50 degrees. The standard deviation was 2.8 degrees and the standard error 0.085 degrees.

Examination of individual subjects reveal that Measurement A increased in twenty of twenty-foud subjects (83.8 percent) during band removal procedures. However, subject 119 exhibited a change in angulation of +0.33 degrees which is within the standard error of the method and therefore considered to have remained unchanged. Four subjects (114, 118, 121 and 122) show a decrease in Measurement A from -0.16 to -3.00 degrees. Subject 122 exhibited a decrease in Measurement A of -0.16 degrees which is within the standard error of the method, and is considered not to have changed. Tables 4 and 9.

Measurement B decreased in twenty of twenty-four subjects. (83.8 percent). Four subjects (114, 118, 121 and 122) showed an increase in Measurement B from +1.0 to +2.0 degrees. Measurement B in all subjects was greater than the standard error of the method. Tables 5 and 9.

Measurement C decreased in fifteen of twenty-four subjects. (62.5 percent). Nine subjects (110, 113, 114, 116, 117, 119, 120 and 121) showed an increase in

Measurement C from +0.5 to +3.3 degrees. Subject 106 exhibited a change in angulation during band removal procedures of -0.16 degrees which is within the standard error of the method and therefore considered to have remained unchanged. Tables 6 and 9.

It is interesting to note that subjects 114 and 121 experienced an increase in protrusion of the central incisors shown in Measurements A, B and C during band removal procedures. Measurements of the records of subjects 118 and 122 indicate an increase in protrusion of the central incisors shown in Measurements A and B during band removal procedures. However, these two subjects experienced a decrease in protrusion of the maxillary incisor shown in Measurement C. Subject 121 exhibited clinical evidence of a tongue thrust habit where-as subjects 114, 118 and 122 did not. Tables 4, 5, 6 and 9.

No effort was made in this study for further comparison of subjects on an individual basis. No effort was made to classify or evaluate the effects of deleterious neuromuscular habits or of other variables present in the sample.

In this study the mean changes in incisor angulations of the three groups indicate that an uprighting of the incisors, in relation to each other and to their respective bony bases occurred during band removal procedures regardless of the method of appliance removal employed. Table 9.

The results of this study are in general agreement with Vorhies' data (10) for the change in angulation of the maxillary and mandibular central incisors during intensive use of a tooth positioner. In 60 percent of the subjects studied by Vorhies there was an increase in the inter-incisal angle. In 80 percent of these subjects the mandibular incisor uprighted, and in 50 percent of the subjects the maxillary central incisor uprighted.

Cole (6), Litowitz (7), Stackler (8) and Wallman (9), indicate in their studies that there is a tendency for the angulation of the mandibular incisors to increase subsequent to retention with a few exceptions. However, these conclusions are based on incisor-angular changes in subjects who have been out of retention for at least one year, rather than on angular changes which take place during the comparatively short period of time involved in appliance removal. None of the studies reviewed indicate whether the records made at the completion of treatment were before or a short time after appliance removal.

The findings in this study are based on a small sample. Sample selection procedures and the presence of variables which could not be controlled should be considered in interpretation of the findings. The magnitude of angular change during this phase of treatment is small, making interpretation of the results difficult in some cases.

Evidence of a trend in angular change of the incisors during band removal procedures has been presented which should be further defined by subsequent studies. It would be interesting to continue this study on the same subjects and compare the present findings with those at the end of the retention period and one or more years subsequent to the removal of all retention.

The subjects in this study were classified according to Angle's molar relationship. Tabulation of results appear in Table 11.

In 92.9 percent of the subjects with a Class I molar relationship, there was an uprighting of the upper incisor in relation to the mandibular plane and in 71.6 percent an uprighting of the upper incisor in relation to the palatal plane.

In 71.4 percent of subjects with a Class II molar relationship, there was an uprighting of the upper incisor in relation to the lower incisor. In 71.4 percent of Class II subjects there was an uprighting of the lower incisor in relation to the mandibular plane, and in 57.1 percent an uprighting of the upper incisor in relation to the palatal plane.

In 66.7 percent of subjects with a Class III molar relationship, there was an uprighting of the upper incisor in relation to the lower incisor. In 66.7 percent of

Class III subjects there was an uprighting of the lower incisor in relation to the mandibular plane, and in 66.7 percent an uprighting of the upper incisor in relation to the palatal plane.

Subjects were also classified according to extraction or non-extraction treatment. Tabulation of results appear in Table 12.

In 81.3 percent of subjects treated extraction, there was an uprighting of the upper incisor in relation to the lower incisor and an uprighting of the lower incisor in relation to the mandibular plane. In 62.5 percent of subjects treated extraction there was an uprighting of the upper incisor in relation to the palatal plane.

In 87.5 percent of subjects treated non-extraction there was an uprighting of the upper incisor in relation to the lower incisor and an uprighting of the lower incisor in relation to the mandibular plane. In 75 percent of subjects treated non-extraction there was an uprighting of the upper incisor in relation to the palatal plane.

V. SUMMARY AND CONCLUSIONS

A cephalometric roentgenographic investigation was conducted on three groups of orthodontic patients to determine the changes in angulation of the maxillary and mandibular central incisor teeth accompanying removal of full banded appliances. Three different procedures of appliance removal were compared.

As a result of this study several observations were made:

1) The interincisal angle increased an average of +5.1 degrees with band removal procedures regardless of the method employed.
2) The axial inclination of the mandibular central incisor in relation to the mandibular plane decreased an average of -3.2 degrees with band removal procedures regardless of the method employed.
3) The axial inclination of the maxillary central incisor in relation to the palatal plane decreased an average of -1.4 degrees with band removal procedures regardless of the method employed.

4) No significant difference was found in the angular change of the maxillary and mandibular incisor relation between patients of the three groups using three different procedures of appliance removal.

5) The interincisal angle increased with band removal procedures in a higher percent of Class I subjects, than in Class II or III subjects.

6) The axial inclination of the mandibular central incisor in relation to the mandibular plane decreased with band removal procedures in a higher percent of Class I subjects than in Class II or III subjects.

7) The axial inclination of the maxillary central incisor in relation to the palatal plane decreased with band removal procedures in a higher percent of Class I and III subjects than in Class II subjects.

8) Non-extraction subjects exhibit a higher percent of uprighting of the incisors during band removal procedures than extraction subjects.

TABLE 1

SUMMARY OF SAMPLE CHARACTERISTICS

GROUP	NUMBER OF PATIENTS	AGE RANGE		MEAN AGE AT INITIAL RECORD		SEX	EXTRACTION RECORD	MOLAR RELATIONSHIP (ANGLE)
		Years	Months	Years	Months			
I	9	12 to 16	6 to 9	14	11	3 Males 6 Females	3 Non-extraction 6 Extraction	7 Class I 1 Class II 1 Class III
II	10	12 to 24	8 to 0	16	7	2 Males 8 Females	3 Non-extraction 7 Extraction	7 Class I 1 Class II 2 Class III
III	5	14 to 16	4 to 0	14	8	1 Male 4 Females	2 Non-extraction 3 Extraction	5 Class II
TOTAL	24	12 to 24	6 to 0	15	4	6 Males 18 Females	8 Non-extraction 16 Extraction	14 Class I 7 Class II 3 Class III

TABLE 2

APPLIANCE REMOVAL PROCEDURE

APPOINTMENT	INTERVAL IN WEEKS			BANDS REMOVED			APPLIANCE PLACED		
	GROUPS			GROUPS			GROUPS		
	I	II	III	I	II	III	I	II	III
1	-	-	-	75421 | 12457 75421 | 12457	all bands	7654 | 4567 7654 | 4567	arch wires	Kesling positioner	sectional arches
2	3	1	4	none	none	321 | 123	adjustment	adjustment	maxillary sectional arch
3	3	4	3	63 | 36 63 | 36	none	321 | 123	none	adjustment	mandibular retainer
4	3	3	3	none	none	none	retainers	retainers	maxillary retainer

TABLE 3

INTERVAL BETWEEN ROENTGENOGRAPHIC RECORDS

GROUP	MEAN TIME IN DAYS	RANGE IN DAYS
I	61.2	54 to 84
II	68.1	40 to 119
III	101.6	89 to 117
TOTAL	72.5	40 to 119

TABLE 4

MEASUREMENT (A)--THE ANGULAR CHANGE OF THE MAXILLARY CENTRAL INCISOR IN RELATION TO THE MANDIBULAR CENTRAL INCISOR

GROUP	PATIENT IDENTIFICATION	TRACING S.D. = 1.068			MEAN $S.E._{\bar{x}}$ = 0.616
		1	2	3	
I	101	+3.0	+5.5	+5.0	+4.50
	102	+5.5	+5.5	+6.5	+5.83
	103	+5.0	+5.0	+5.0	+5.00
	104	+4.0	+5.5	+9.5	+6.33
	105	+7.5	+9.0	+9.0	+8.50
	106	+5.5	+5.0	+4.0	+4.83
	107	+3.5	+6.0	+7.0	+5.50
	108	+2.5	+2.0	+3.5	+2.66
	109	+12.0	+10.5	+12.0	+11.50
II	110	+3.5	+3.5	+1.5	+2.83
	111	+10.0	+10.0	+11.0	+10.33
	112	+10.0	+10.0	+10.5	+10.16
	113	+4.5	+5.0	+5.5	+5.0
	114	-2.0	-4.0	-3.0	-3.00
	115	+15.0	+11.0	+12.0	+12.66
	116	+5.0	+5.0	+3.0	+4.33
	117	+1.0	+2.0	+2.0	+1.66
	118	-0.5	-1.0	-0.5	-0.66
	119	+0.0	+1.0	0.0	+0.33
III	120	+1.5	+1.5	+1.0	+1.33
	121	-2.0	-2.5	-2.0	-2.16
	122	0.0	+0.5	-1.0	-0.16
	123	+8.5	+9.5	+10.5	+9.33
	124	+9.5	+10.0	+11.0	+10.16

Note: All measurements are in degrees

Positive sign indicates an increase in the interincisal angle

Negative sign indicates a decrease in the interincisal angle

TABLE 5

MEASUREMENT (B) -- THE ANGULAR CHANGE OF THE MANDIBULAR CENTRAL INCISOR IN RELATION TO THE MANDIBULAR PLANE

GROUP	PATIENT IDENTIFICATION	TRACING S.D. = 0.890			MEAN $S.E._{\bar{x}} = 0.519$
		1	2	3	
I	101	-5.5	-5.0	-4.5	-5.00
	102	-3.5	-3.5	-3.5	-3.50
	103	-4.0	-3.0	-3.0	-3.33
	104	-0.5	-0.5	-4.0	-1.66
	105	-6.5	-6.0	-5.5	-6.00
	106	-5.0	-4.0	-3.0	-4.0
	107	-1.0	-3.0	-3.0	-2.33
	108	0.0	-1.5	-1.5	-1.00
	109	-5.5	-4.0	-5.0	-4.83
II	110	-6.0	-5.0	-4.0	-5.00
	111	-4.5	-4.0	-4.5	-4.33
	112	-7.0	-7.5	-7.5	-7.33
	113	-5.0	-5.0	-5.5	-5.16
	114	+1.0	+1.0	+1.0	+1.00
	115	-11.0	-7.0	-7.5	-8.50
	116	-5.0	-5.5	-5.5	-5.33
	117	-2.5	-3.0	-3.0	-2.83
	118	+1.0	+2.0	+2.0	+1.66
	119	-2.0	-2.5	-1.0	-1.80
III	120	-3.0	-1.5	-1.5	-2.00
	121	+1.0	+2.5	+2.5	+2.00
	122	+0.5	+0.5	+2.0	+1.00
	123	-3.0	-4.0	-4.0	-3.66
	124	-3.5	-3.5	-5.0	-4.00

Note: All measurements are in degrees

Positive sign indicates an increase in angulation of the lower incisor

Negative sign indicates a decrease in angulation of the lower incisor

TABLE 6

MEASUREMENT (C) -- THE ANGULAR CHANGE OF THE MAXILLARY CENTRAL INCISOR IN RELATION TO THE PALATAL PLANE

GROUP	PATIENT IDENTIFICATION	TRACING S.D. = 0.738 1	2	3	MEAN S.E.$_{\bar{x}}$ = 0.420
I	101	+2.5	0.0	0.0	+0.83
	102	-1.0	-1.5	-2.0	-1.50
	103	-0.5	-1.5	-2.0	-1.33
	104	-4.0	-5.0	-4.5	-4.50
	105	0.0	-3.0	-2.5	-1.83
	106	0.0	-0.5	0.0	-0.16
	107	-3.0	-4.0	-4.0	-3.66
	108	-2.5	0.0	-1.5	-1.33
	109	-6.0	-6.5	-7.0	-6.50
II	110	+3.5	+3.5	+3.0	+3.33
	111	-5.5	-6.0	-5.5	-5.66
	112	-2.0	-2.5	-2.5	-2.16
	113	+2.0	0.0	+1.0	+1.00
	114	+2.0	+4.5	+3.5	+3.33
	115	-3.0	-5.0	-4.5	-4.16
	116	+1.0	+1.0	+2.0	+1.33
	117	+1.0	+1.0	+1.0	+1.00
	118	-1.0	-0.5	-1.0	-0.83
	119	+1.5	+1.0	+1.0	+1.16
III	120	+0.5	+0.5	+0.5	+0.50
	121	+0.5	+1.0	0.0	+0.50
	122	-0.5	-1.0	-0.5	-0.66
	123	-5.0	-5.0	-5.0	-5.00
	124	-5.5	-6.5	-6.5	-6.16

Note: All measurements are in degrees

Positive sign indicates an increase in angulation of the upper incisor

Negative sign indicates a decrease in angulation of the upper incisor

TABLE 7

SUMMARY OF GROUP MEANS

MEASUREMENT	GROUP		
	I	II	III
A	+6.07	+4.96	+3.70
B	-3.52	-4.73	-1.33
C	-2.22	-0.16	-2.16

Note: All measurements are in degrees

Positive sign indicates an increase in angulation

Negative sign indicates a decrease in angulation

TABLE 8

SUMMARY OF ANALYSIS OF VARIANCE FOR MEASUREMENTS A, B, AND C, IN THE THREE GROUPS STUDIED

MEASUREMENT A

SOURCE OF VARIANCE	SUM OF SQUARES	df	MEAN SQUARE	F
Between groups	18.50	2	9.25	.53
Within groups	368.74	21	17.56	
Total	287.24	23		

MEASUREMENT B

SOURCE OF VARIANCE	SUM OF SQUARES	df	MEAN SQUARE	F
Between groups	21.48	2	10.74	1.51
Within groups	149.32	21	7.11	
Total	170.80	23		

MEASUREMENT C

SOURCE OF VARIANCE	SUM OF SQUARES	df	MEAN SQUARE	F
Between groups	24.20	2	12.10	1.55
Within groups	163.52	21	7.79	
Total	187.70	23		

TABLE 9

DISTRIBUTION OF PATIENTS ACCORDING TO MOVEMENT OF THE INCISORS

GROUP	PATIENT IDENTIFICATION	MEASUREMENT A	B	C
I	101	-	-	+
	102	-	-	-
	103	-	-	-
	104	-	-	-
	105	-	-	-
	106	-	-	-
	107	-	-	-
	108	-	-	-
	109	-	-	-
II	110	-	-	+
	111	-	-	-
	112	-	-	-
	113	-	-	+
	114	+	+	+
	115	-	-	-
	116	-	-	+
	117	-	-	+
	118	+	+	-
	119	-	-	+
III	120	-	-	+
	121	+	+	+
	122	+	+	-
	123	-	-	-
	124	-	-	-

Note: Positive sign indicates an increase in protrusive relation of the incisors.

Negative sign indicates a decrease in the protrusive relation of the incisors.

TABLE 10

SUMMARY OF MEASUREMENTS A, B, AND C,
OF COMBINED GROUPS I, II AND III

MEASUREMENT	MEAN	RANGE	STANDARD DEVIATION	STANDARD ERROR OF THE MEAN
A	+5.1	-2.16 to +12.66	4.10	.125
B	-3.2	+2.00 to - 8.50	2.72	.105
C	-1.4	+3.33 to - 6.50	2.80	.085

Note: All measurements in degrees

Positive sign indicates an increase in angulation

Negative sign indicates a decrease in angulation

TABLE 11

PERCENT OF SUBJECTS IN MEASUREMENTS A, B, AND C, EXHIBITING UPRIGHTING OF INCISORS

MOLAR RELATIONSHIP (ANGLE)	MEASUREMENT		
	A	B	C
CLASS I	92.9	92.9	71.6
CLASS II	71.4	71.4	57.1
CLASS III	66.7	66.7	66.7

Note: Subjects classified according to angle molar relation

PERCENT OF SUBJECTS IN MEASUREMENTS A, B, AND C, EXHIBITING UPRIGHTING OF INCISORS

TREATMENT	MEASUREMENT		
	A	B	C
EXTRACTION	81.3	81.3	62.5
NON-EXTRACTION	87.5	87.5	75.0

Note: Subjects classified according to extraction or non-extraction treatment.

CHART 1

SAMPLE CHARACTERISTICS

GROUP	PATIENT IDENTIFICATION	AGE AT INITIAL RECORD		SEX	EXTRACTION RECORD	MOLAR RELATIONSHIP (ANGLE)
		Years	Months			
I	101	12	6	F	-	II
	102	12	11	F	-	I
	103	14	8	F	4 Bicuspids	I
	104	15	11	M	"	I
	105	15	6	F	"	I
	106	15	7	M	1 Lower Ant.	I
	107	15	10	M	-	I
	108	15	11	F	4 Bicuspids	III
	109	16	9	F	"	I
II	110	12	8	F	-	I
	111	13	4	F	4 Bicuspids	I
	112	14	0	F	-	I
	113	14	7	F	4 Bicuspids	I
	114	14	10	F	-	I
	115	15	1	F	4 Bicuspids	I
	116	16	10	F	"	II
	117	17	8	F	"	I
	118	23	4	M	"	III
	119	24	0	M	"	III
III	120	14	4	F	2 Bicuspids	II
	121	14	4	F	4 Bicuspids	II
	122	14	4	M	"	II
	123	14	7	F	-	II
	124	16	0	F	-	II

CHART 2

INTERVAL BETWEEN ROENTGENOGRAPHIC RECORDS

GROUP	PATIENT IDENTIFICATION	TIME INTERVAL IN DAYS
I	101	77
	102	56
	103	56
	104	84
	105	56
	106	56
	107	54
	108	56
	109	56
II	110	67
	111	67
	112	88
	113	90
	114	48
	115	51
	116	57
	117	119
	118	54
	119	40
III	120	93
	121	100
	122	117
	123	89
	124	109

CHART 3

APPLIANCE REMOVAL PROCEDURES

GROUP I

A) First appointment

1) Arch wires removed

2) Lateral cephalometric film obtained

3) Maxillary and mandibular bands removed except cuspid and molar bands

4) Arch wires replaced and ligated to the remaining bands

B) Second appointment (three weeks later)

1) Adjustment of the appliance to close the remaining spaces

C) Third appointment (three weeks later)

1) Removal of the remaining appliance

2) Impressions made for construction of the maxillary and mandibular retainers

D) Fourth appointment (three weeks later)

1) Lateral cephalometric film obtained

2) Placement of the maxillary and mandibular retainers

GROUP II

A) First appointment

1) Lateral cephalometric film obtained

2) Complete removal of maxillary and mandibular appliance

CHART 3 - Continued

3) Placement of Kesling tooth positioner (11)

B) Second appointment (one week later)

1) Adjustment of the tooth positioner if necessary

C) Third appointment (four weeks later)

1) Adjustment of tooth positioner if necessary

2) Impressions made for construction of the maxillary and mandibular retainers

D) Fourth appointment (three weeks later)

1) Lateral cephalometric film obtained

2) Maxillary and mandibular retainers placed

GROUP III

A) First appointment

1) Lateral cephalometric film obtained

2) Maxillary and mandibular appliances removed from molars and bicuspids leaving bands and sectional arch wires in place on the maxillary and mandibular central and lateral incisors and cuspid teeth

B) Second appointment (four weeks later)

1) Removal of remaining mandibular appliance

2) Impressions made for construction of the mandibular retainer

C) Third appointment (three weeks later)

1) Placement of the mandibular retainer

2) Removal of the remaining maxillary appliance

3) Impressions made for construction of the maxillary retainer

D) Fourth appointment (four weeks later)

1) Placement of the maxillary retainer

E) Fifth appointment (four weeks later)

1) Lateral cephalometric film obtained

CHART 4

ANATOMIC STRUCTURES AND LANDMARKS IDENTIFIED AND TRACED

The anatomic structures and landmarks identified and traced are listed below. (12)

A. The external contour of the occipital bone extending from the lambdoidal suture to the area visible as the right and left contours of the mastoid processes.

B. The external contour of the frontal bone.

C. The external contour of the nasal bone from nasion downward to where it begins to form the lateral wall of the nasal cavity.

D. The contour of sella-turica between the anterior and posterior clinoid processes.

E. The contour of the pterygomaxillary fissure.

F. The lateral and inferior contours of the orbits as formed by the zygomatic bone.

G. The maxillo-zygomatico-temporal sulcus, seen on norma-lateralis as a line extending from the cribriform plate down to the floor of the nasal cavity and curving upward toward orbitale.

H. The entire bony contour of the hard palate including the anterior and posterior nasal spines.

I. The external contour of the mandible, including the posterior contour of the ramus, the inferior contour

CHART 4 - Continued

of the body, and the external contour of the symphus of the mandible, as seen on norma-lateralis.

M. Menton - the lower most point on the symphyseal shadow.

Go. Gonion - the point on the bony contour of the gonial angle, located by bisection of the angle formed by mandibular base line and the posterior ramal line.

Mandibular plane - formed by a line joining menton and gonion.

Palatal plane - formed by a line joining the anterior and posterior nasal spines.

J. The average contour of maxillary left and right central incisors.

K. The average contour of the left and right mandibular central incisors.

L. Maxillary central incisor long axis - an arbitrary long axis, formed by a line bisecting the incisal and apical contours of the tracing of the maxillary central incisor.

N. Mandibular central incisor long axis - an arbitrary long axis formed by a line bisecting the incisal and apical contours of the tracing of the mandibular central incisor.

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