The Effect Of Orthodontic Treatment On Alveolar Bone Adjacent To The Cemento-Enamel Junction

Donald H. Baxter, D.D.S., M.S.D.
Syracuse, New York

Introduction

The effect of orthodontic forces upon the alveolar bone proper has been a subject of investigation for many years. The majority of the research has been of a histological nature. Such studies have been concerned with the early reaction of alveolar bone to orthodontic forces applied to the teeth. Little attention has been directed toward the condition of the alveolar bone after it has been subjected to long periods of orthodontic tooth movement and after a full course of orthodontic treatment has been completed.

The literature abounds with studies which indicate that a considerable amount of pathological destruction of the alveolar bone proper results from forces used in moving teeth orthodontically. Much of the literature on this subject[16,19,20,36] would lead one to believe that there was a particularly large amount of alveolar bone lost permanently at the height of the alveolar bone proper as a result of the forces used in the modern orthodontic mechanisms. If this is true, it presents a rather pessimistic outlook for the orthodontist when he considers that he may be destroying the much needed tooth supporting bone and thus "aging the denture". It would be of value to know whether or not modern orthodontic treatment procedures do actually cause permanent bone loss at the alveolar crest and whether there is any difference between treatment procedures in this respect. What happens to the alveolar bone proper when teeth are extruded? What happens to the alveolar bone proper adjacent to extraction areas?

The purpose of this study was to determine by use of intraoral bite wing roentgenographs: (1.) The anatomical relationship between the alveolar bone proper and the cemento-enamel junction. (2) The amount of change in height of the alveolar bone proper which is effected by orthodontic tooth movement. (3) The difference, if any, in the change in height of the alveolar bone proper between cases treated by nonextraction methods and cases treated by extraction procedures. (4) The difference, if any, in the change in height of alveolar bone proper between cases treated by the edgewise appliance and those treated by the Begg appliance.

Presented before the North Atlantic Component of the Angle Society April, 1965.

Review of the Literature

A summary of the literature will be given on resorption and deposition of alveolar bone as influenced by orthodontic forces and by systemic and hereditary factors. Before this is presented it is appropriate to review the more recent literature on the anatomy of the alveolar bone and to define its component parts as they are referred to in this study.

I. The Alveolar Bone

Alveolar bone proper: The alveolar bone proper is the thin, lamellated bone

Fig. 1 Photograph of a typical intraoral bitewing roentgenograph. Arrows indicate the structures described in Fig. 2.

which surrounds the root of the tooth and gives attachment to the principal fibers of the periodontal membrane.[21] Lamina dura is another term for this specific bone. In roentgenographs it appears as a thin white line (Fig. 1).[20,21,30] Histological analysis has shown that the newly-formed bone on the periodontal surface of the alveolar bone proper which is deposited during tooth eruption, mesial drift and orthodontic movement is fibrous (bundle bone). This soon becomes reorganized into lamellar bone. In roentgenographs newly-formed fibrous bone appears thick and radiopaque. The reorganized lamellar bone appears thinner and much less radiopaque in roentgenographs.[12]

The most occlusal edge of the alveolar bone proper at the mesial and distal of each tooth, as observed in intraoral bitewing roentgenographs, is referred to here as *point* Z. This specific

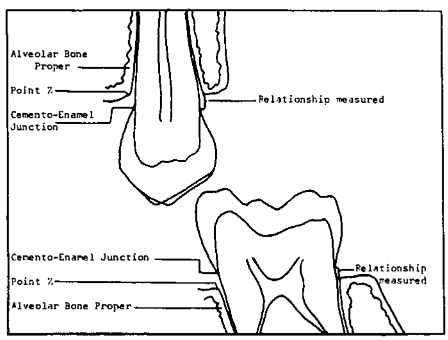

Fig. 2 Schematic drawing of structures studied in intraoral bitewing roentgenograph.

area of bone and its relationship to the cemento-enamel junction are investigated in this study (Figs. 1 and 2).

The alveolar bone proper is partly lamellated and partly bundle bone and has been described as the smallest amount of lamellated bone containing Haversian system in the body. It is perforated by many openings which carry the interalveolar blood vessels and nerves to the periodontal membrane.[21]

Supporting alveolar bone: The bone which surrounds the alveolar bone proper consists of two parts, (1) the compact bone forming the vestibular and oral cortical plates of the alveolar process and (2) the spongy bone between these two plates and the alveolar bone proper. The spongy bone is arranged in trabeculae in the direction of the stresses of mastication.[21]

Alveolar crest: The section of interproximal alveolar bone which includes the free edge of the alveolar process is called the alveolar crest. Again in this study the specific area of investigation is that occlusal portion of alveolar bone proper on the alveolar crest located immediately adjacent to the mesial and distal of the tooth, in this study called point Z.

Weinman[37] describes the development of the alveolar crest during the second and third stage of tooth eruption as a formation of parallel trabeculae of bone, separated by marrow spaces, "The simultaneous growth at the fundus as well as at the alveolar crest throughout the life span of the tooth indicates the tendency to preserve a relatively constant depth of the alveolus".

Ritchey and Orban[28,29] described a constant relationship between the free border of the alveolar bone proper and the cemento-enamel junction. They have shown that the shape of the outline of the alveolar crest, as seen in intraoral roentgenographs, depends upon the position of the adjacent teeth, the form of the crowns of the teeth, and the shape of the cemento-enamel junction and the width of the teeth. A flat alveolar crest is normally found in areas where the adjacent crowns of the teeth are strongly convex, e.g., in the buccal segments, and a more pointed alveolar crest is found between teeth which have flat contact areas and cemento-enamel junctions that are extremely convex toward the incisal, e. g., lower incisor area. When teeth are tipped mesially, as is normal in the buccal segments, the alveolar crests are sloped obliquely and thus maintain the relationship of the cemento-enamel junction to the free border of the alveolar bone proper.[28,29]

The alveolar crest is above the cemento-enamel junction early in eruption of the tooth but later, during passive eruption, the crest becomes located apically to the cemento-enamel junction.[9]

Osteoid tissue: When bone has been damaged and is undergoing repair, the new bone laid down is at first an immature uncalcified organic matrix called osteoid tissue. This bone is highly resistant to resorption.[18,20,38] It also remains relatively radiolucent until it begins to calcify. As a result, the roentgenographic visibility of newly-formed bone lags about two or three weeks behind the bone's actual formation.[21,38] According to Reitan,[24] supporting tissues in the young (12 years old) are in a state of proliferation even if tooth movement has not been performed. Along the inner alveolar bone surface we may observe layers of newly formed osteoid. This osteoid covers an underlying area of newly-calcified bundle bone.

The Cemento-enamel Junction: The term cemento-enamel junction as used in this paper refers to the outline of this junction at the mesial and distal of the tooth as observed in the intraoral bitewing roentgenographs. At the mesial and distal of each tooth, the cemento-enamel junction is occlusally convex. The most occlusal part of this convexity is the point measured in this study.

II. Resorption and Deposition of Alveolar Bone Proper as Influenced by Orthodontic Forces

There are several local factors which influence resorption and deposition of the alveolar bone proper, inflammation due to local infection and mechanical irritation, variation in function of the masticatory apparatus, and forces used in orthodontic tooth movement. The latter will be considered here.

Reviews of the literature on the *early* tissue response to orthodontic tooth movement have been presented by Stuteville,[35] Oppenheim,[19] Reitan,[23] Halderson,[10] and Storey.[34] Most of the work has been of a histological nature and has been concerned with the early phase of tissue reaction to tooth movement. The greatest part of the tooth movement which is accomplished by orthodontic mechanics results in tipping of the tooth with the fulcrum of the movement located slightly occlusally to the apex of the root. This consequently results in affecting the alveolar bone proper at its free edge. The initial reaction of the periodontal tissue in this area to the forces applied to a tooth within the limits of tolerance is manifested in resorption of alveolar bone proper on the side of pressure and deposition of bone on the traction side.[4,7,8,18,19,23,31,34,38]

The *initial* tissue reaction varies with the nature of the force. Referring to continuous forces within the tolerance of the tissues, Reitan[23] states, "The initial tissue reaction called forth in young patients incident to application of continuous forces, consists of a deposition and widening of osteoid tissue at the tension side and bone resorption rapidly increasing with time on the pressure side". When strong forces are used in excess of the tolerance of the tissues, then some pathological responses result. The tooth movement crushes the periodontal membrane and produces necrosis of the periodontal fibers and alveolar bone proper at the pressure side (primarily at the free edge of alveolar bone proper); the bone appears aplastic and undergoes resorption at this area.[20,35] On the tension side the periodontal space is widened, many fibers are torn and vessels ruptured, new spicules of bone develop in the form of osteoid tissue, and undermining resorption (resorption from the rear) begins.[16,20,35,38]

Reitan has described the *initial* tissue response to tooth movement in detail. In tipping action[25,26] and combination bodily and tipping movement[27] he demonstrates that a compressed osteoid tissue develops which is cell free (and sometimes referred to as hyalinized area) on the pressure side of the root even if the force applied is light (25 grams). There appears to be less osteoid tissue formation in bodily movement than in tipping of a tooth. This cell-free osteoid tissue does not seem to resorb directly but remains for two or three weeks until undermining resorption takes over, histologically the undermining resorption is characterized by presence of many osteoclasts.[25,26,27] Interestingly, Reitan indicates that after this initial tissue reaction with continuous light force the tooth moves more rapidly than with heavy and intermittent force.

The forces applied to a tooth may vary considerably. The response of the periodontal tissues depends upon the amount of force, duration of force, and the distance through which it is active.[10,16,17,34] It has been emphasized that duration of force influences the amount of resorption and deposition of alveolar bone more than the amount of force applied.[23]

The rate of movement of teeth or the rate at which the bone undergoes resorption and deposition depends upon the amount of force used and the length of time it is applied.[23,34] Storey[34] indicated that on maxillary cuspids an optimum range of force of 200 to 162 grams would produce a maximum rate of tooth movement.

It has been suggested that the ideal forces for orthodontic tooth movement should remain below 25 grams per square centimeter (capillary pressure.)[16] This cannot possibly be carried out clinically by use of present orthodontic appliances.[10,16,18] Actually we depend upon some capillary collapse to facilitate the tissue reactions necessary for tooth movement.[4]

It is impossible to affix a value to the forces which are within the limits of tolerance because they vary among individuals and depend upon hereditary predisposition and systemic factors. Logically, a force may be considered beyond the limit of tolerance when it produces necrosis of the tissue on the side of pressure and resorption on the side of tension. According to Huettner and Whitman[11] light forces produce the least amount of damage to periodontal tissues.

It is appropriate to consider the general physiological response of bone to applied forces to understand fully the bone reactions discussed above. Bone differs in its structure depending upon whether it is primarily subjected to tension or pressure. It is constructed in adaptation to various pressures and tensions and their direction of application. Anatomically this is expressed in the different tissues which cover bone surfaces; surfaces under pressure are covered by an avascular tissue while areas under tension are covered by vascular tissue. The alveolar bone proper is primarily under tension because forces applied to the tooth are transmitted to the bone as tension via the periodontal fibers. An increase of the normal forces of pressure or tension within limits of tolerance leads to deposition of new bone. If forces are beyond the limits of tolerance, resorption of bone will result whether the force produces pressure or tension. Very slight pressure is needed to cause resorption of bone which is normally adapted to tension.[38]

There has been little research done on the condition of the alveolar bone proper following orthodontic tooth movement and after the physiological and pathological processes have subsided. Some men believe that there is unrepairable damage to the alveolar crest following orthodontic treatment;[19,20,36] another school feels that there are insignificant bone changes sustained after tooth movement.[3]

III. Resorption and Deposition of the Alveolar Bone Proper as Influenced by Systemic and Hereditary Factors

Certain systemic diseases seem to be related to an abnormal amount of alveolar bone resorption.[33] Glickman promoted the idea of a "bone factor" which is a summation of systemic factors influencing alveolar bone health. He states that the "bone factor" may be altered sufficiently to produce alveolar bone destruction without any local cause, "The bone factor envisions systemic participation in all cases of periodontal disease".[6] He also speculated on the relationship of the general adaptation syndrome in response to the cause of periodontal disease. It has been demonstrated by several men that alveolar bone will regenerate following the elimination of pathology and disease.[1,2,32]

It has been evident many times that alveolar bone is dependent in form on the development of the tooth germs and roots. The free border of the alveolar bone proper maintains a constant anatomical relationship with the tooth as shown by Ritchey and Orban[28,29] and Glickman.[7] Glickman,[5] through studies of starvation diets and removal of

TABLE I

	Number	Age Range	Months of Treatment Range	Males	Females	Cl. I	Cl. II Div. 1	Cl. II Div. 2
Nonextraction	15	11.0- 13.7	6-27	6	9	10	2	3
Extraction U-4s	3	11.0- 13.0	18-30	1	2	0	3	0
Extraction U-4s/L-4s Edgewise	32	10.5- 13.0	12-31	11	21	23	9	0
Extraction U-5s/L-5s Edgewise	5	10.5- 12.3	11-22	1	4	5	0	0
Extraction U-4s/L-5s Edgewise	8	11.5- 13.0	17-29	3	5	3	5	0
Extraction U-4s/L-4s Begg	13	11.5 13.0	11-33	3	10	2	11	0

functional antagonists in animals, showed that, as the tooth erupted, the alveolar crest continued to show apposition of bone to maintain its anatomical relationship with the tooth. He pointed out that local causes activate deposition of alveolar bone but that the deposition is regulated by systemic influences.

McLean[13,14] has proposed an interesting biochemical hypothesis as to the mechanism of bone resorption. He points out that, in order to resorb bone, all the matrix, the mineral and serological content must be reduced to a compound which is soluble in water and can be transposed to the blood. He explains that bone resorption is a physiological process as well as pathological and osteoclasts are always present. According to his hypothesis the osteoblast undergoes a change and liberates a histamine-like product which then reduces the ground substances to elaborate another material which sends the osteoclast into action as the resorbing agent. He believes this to be an enzymatic mechanism.

Materials and Methods

Intraoral bitewing roentgenographs from seventy-six completed orthodontic cases were studied. Sixty-one cases were selected at random from the files of the University of Washington Department of Orthodontics and fifteen cases were obtained from private practice. Fifteen cases were treated by nonextraction procedures using the edgewise appliance and fifty-five cases were treated by extraction of bicuspid teeth. Further, among the extraction cases forty-eight were treated by edgewise appliance technique and thirteen by Begg appliances. The distribution of the sample as to type of treatment, age and sex of the patient, length of treatment, and original malocclusion is given in Table I.

Fifty-three cases were treated by use of the edgewise appliance. The primary effort with this appliance method was to retract cuspids with minimal amount of tipping. Whereas, with Begg technique, rapid tipping of the cuspids was the objective followed by uprighting of the root.

Measurements of the distance from the alveolar bone proper at point Z to the cemento-enamel junction were made on intraoral bitewing roentgenographs taken immediately before treatment and immediately after treatment. The following areas in the right and

TABLE II

	D-3	M-4	D-4	M-5	D-5	M-6	D-6	M-7	Total
Maxilla									
Nonextraction	21	27	28	26	23	25	14	12	176
Extraction U-4s (Edgewise)	55	—	—	79	81	79	65	52	411
Extraction U-5s (Edgewise)	6	6	10	—	—	9	4	4	39
Extraction U-4s (Begg)	11	—	—	19	16	16	12	12	86
Total	93	33	38	124	120	129	95	80	712
Mandible									
Nonextraction	17	19	36	32	30	34	30	25	223
Extraction L-4s (Edgewise)	40	—	—	55	53	58	60	57	323
Extraction L-4s (Begg)	11	—	—	16	18	19	20	20	104
Extraction L-5s (Edgewise)	14	13	23	—	—	25	23	21	119
Total	82	32	59	103	101	136	133	123	769

left sides of the maxilla and mandible were recorded from each set of roentgenographs: distal of the cuspid (D-3), mesial of the first bicuspid (M-4), distal of first biscuspid (D-4), mesial of second bicuspid (M-5), distal of second bicuspid (D-5), mesial of first molar (M-7). The degree of accuracy of measurement was 0.5 mm. The number of measurements made of each area is shown in Table II.

From tests made on a dried human skull it was found that the most occlusal point of the convexity of the cemento-enamel junction on the mesial and distal of the tooth was the point measured on the roentgenographs.

Before and after treatment lateral cephalometric roentgenographs were used to study the amount and character of orthodontic tooth movement that occurred in the first bicuspid extraction cases.

Findings and Discussion

This study is primarily concerned with the ultimate condition of the alveolar bone proper after major orthodontic treatment.

I. Validity of the Method of Investigation

A test of the method was carried out on a dried human skull. The specimen was anchored and a series of intraoral bitewing roentgenographs was taken in which the angulation of the x-ray beam varied in both the horizontal and vertical planes. The influence of the change in angulation upon the accuracy of measurements from the cemento-enamal junction to the alveolar bone proper at point Z in the various areas was calculated. The standard settings for bitewing roentgenographs used were a horizontal angle of 60° and a vertical angle of +8°. A range of variation of the horizontal angle of plus or minus 10° from the standard gave consistent measurements to the nearest 0.5 mm; beyond this range accuracy decreased. A range of variation of the vertical angle of plus or minus 8° from the standard gave consistent measurements to the nearest 0.5mm; beyond this range accuracy decreased. The exposure time had little effect upon the roentgenographic interpretation.

TABLE III
ANATOMICAL MEASUREMENT IN MILLIMETERS BETWEEN THE RELATIONSHIP OF ALVEOLAR BONE PROPER AT POINT Z AND THE CEMENTO-ENAMEL JUNCTION

	D-3	*M-4*	*D-4*	*M-5*	*D-5*	*M-6*	*D-5*	*M-7*
Maxilla (Edgewise)								
Mean	0.63	0.53	0.82	0.28	0.61	0.40	0.40	0.38
S. D.	0.49	0.51	0.35	0.61	0.49	0.59	0.48	0.84
S. E.m	0.05	0.09	0.06	0.06	0.05	0.06	0.05	0.10
Mandible (Edgewise)								
Mean	0.54	0.11	0.53	0.34	0.27	0.40	0.28	0.29
S. D.	0.49	0.64	0.43	0.44	0.56	0.44	0.52	0.38
S. E.m	0.06	0.11	0.06	0.05	0.06	0.04	0.05	0.04

The bitewing roentgenographs were used because of the standardized technique in taking them and the more than ample range of latitude and longitude which could be allowed and yet produce accuracy in the interpretation.

The accuracy with which bone loss could be determined by roentgenographic interpretation was found to be to the nearest 0.5 mm. This was done by comparing measurements from intraoral bitewing roentgenographs with direct measurements of burr cuts made on a dried human skull specimen. A bone loss of less than 0.5 mm was not considered a significant amount.

II. Measurement of the Anatomical Relationship of the Alveolar Bone Proper at Point Z to the Cemento-enamel Junction

There is no record in the literature of the anatomical distance between the alveolar bone proper at point Z and the cemento-enamel junction at the mesial and distal of the teeth. Such measurements were obtained before beginning orthodontic treatment from sixty-three patients used in this study. The age range of this group of children was from ten years to sixteen and one-half years. The means, standard deviations, standard errors of the means, and the ranges are recorded on Table III. The mean relationships show a range of 0.28 mm to 0.82 mm in the maxilla and 0.11 mm to 0.86 mm in the mandible. The standard deviation is less than 0.84 mm in the maxilla and less than 0.64 mm in the mandible. In millimeters of measurement, the standard deviations are small. These figures demonstrate a fairly constant relationship between the alveolar bone proper at point Z and the cemento-enamel junction.

III. Change in the Relationship of the Alveolar Bone Proper at Point Z to the Cemento-Enamel Junction Subsequent to Orthodontic Treatment

The change in the relationship of the alveolar bone proper to the cemento-enamel junction subsequent to orthodontic treatment was obtained by measuring the distances from point Z to the cemento-enamel junction on the before and after treatment roentgenographs. The difference between the two measurements indicated the amount of bone loss, if any.

The seventy-six cases were divided into treatment groups, maxillary nonextraction, maxillary first bicuspid extraction (edgewise treatment), maxillary first bicuspid extraction cases (Begg treatment), maxillary second bicuspid extraction (edgewise treatment), and the same groups for the mandible.

Statistical data, means, standard deviations, standard errors of the means, and ranges were computed for the areas measured (Tables IV and V).

It was of particular interest to determine the effect upon the alveolar bone proper at point Z of moving teeth into extraction areas. First bicuspid extraction cases were compared with nonextractions, and extraction cases with edgewise treatment were compared with Begg extraction cases (Tables IV and V).

Generally, the means indicate a slight amount of bone loss of *less* than 0.5 mm; most of the standard deviations are less than 0.5 mm. The pattern of distribution is similar in all groups.

Specifically, in the maxillary groups the greatest mean bone loss (.57 mm) occurred at the mesial of the *second bicuspid* (M-5) in the first bicuspid extraction edgewise treatment group. The largest standard deviation (.83 mm) occurs in the same area. Interestingly, in the extraction Begg treatment cases the mean change in bone height was 0.0 at distal of cuspids and mesial of second bicuspid.

The mandibular measurements are generally less than those for the maxilla. The largest mean bone loss (.32 mm) occurs at the distal of the cuspid (D-3) in the second bicuspid extraction (edgewise treatment group). The standard deviation (.48 mm) is small. The extraction cases with edgewise treatment or Begg treatment compare favorably.

There is no mean or standard deviation in this study which could indicate a "large amount of bone destruction" (only one above 0.5 mm) of the alveolar bone proper at point Z, as is proven in the statistical analysis.

The change in the relationship of point Z to the cemento-enamel junction ranged from —2.0 mm to +2.5 mm for the entire study. The greatest range (—2.0 mm to +2.0 mm) in any one area occurred in the maxilla at the mesial of the first molar in the first bicuspid extraction group. Actually, from the entire study of more than one thousand measurements there was one measurement of —2.0 mm, four measurements of —1.5 mm, forty-five measurements of —1.0 mm, one measurement of +2.5 mm, five measurements of +2.0 mm, and nineteen measurements of +1.5 mm. The majority of measurements were between —0.5 mm and +1.0 mm, a small distribution about the means as was indicated by the standard deviations.

It was of particular interest to evaluate whether there was any difference in the effect upon the change in the relationship of point Z to the cemento-enamel junction between nonextraction and extraction treatment and between extraction edgewise and extraction Begg cases. The Student "t" test was applied to evaluate the difference between the means of the various groups.

The findings show that there is no difference in change in the relationship of point Z to the cemento-enamel junction between extraction and nonextraction cases, and between edgewise and Begg cases.

The differences in change in the relationship of point Z to the cemento-enamel junction in bone areas adjacent to extraction of first bicuspids in the edgewise cases were compared with comparable areas in nonextraction cases, The Student "t" test was used to determine that no significant difference exists between these two groups in any of the areas studied. Therefore, moving teeth toward an extraction area had no specific sustained effect upon the alveolar bone proper at point Z.

Extraction cases with the Begg appliance demonstrated similar relationships in axial inclination of bicuspids and cuspids. Interestingly enough, the rapid

TABLE IV
THE AMOUNT OF CHANGE IN MILLIMETERS FOLLOWING TREATMENT IN THE MAXILLA

	D-3	*M-4*	*D-4*	*M-5*	*D-5*	*M-6*	*D-6*	*M-7*
Maxilla Nonextraction (Edgewise)								
Mean	0.21	0.27	-0.09	0.38	0.06	0.24	-0.12	0.50
S. D.	0.37	0.34	0.45	0.61	0.37	0.41	0.34	0.45
S. E.m	0.08	0.07	0.09	0.12	0.08	0.08	0.09	0.14
Extraction U-4s (Edgewise)								
Mean	0.27	—	—	0.57	0.04	0.13	-0.04	0.20
S. D.	0.42	—	—	0.83	0.54	0.59	0.41	0.57
S. E.m	0.06	—	—	0.09	0.06	0.06	0.05	0.08
Extraction U-5s (Edgewise)								
Mean	0.25	0.42	0.00	—	—	0.11	0.50	0.12
S. D.	0.38	0.34	0.02	—	—	0.51	0.79	0.54
S. E.m	0.19	0.15	0.07	—	—	0.18	0.46	0.31
Extraction U-4s (Begg)								
Mean	0.0	—	—	0.0	0.17	0.27	0.14	0.14
S. D.	0.15	—	—	0.08	0.12	0.21	0.21	0.25
S. E.m	0.04	—	—	0.02	0.03	0.01	0.06	0.07

TABLE V
THE AMOUNT OF CHANGE IN MILLIMETERS FOLLOWING TREATMENT IN THE MANDIBLE

	D-3	*M-4*	*D-4*	*M-5*	*D-5*	*M-6*	*D-6*	*M-7*
Mandible Nonextraction (Edgewise)								
Mean	0.12	0.18	0.10	-0.02	0.07	0.19	0.10	0.04
S. D.	0.27	0.43	0.31	0.42	0.34	0.45	0.30	0.31
S. E.m	0.07	0.10	0.05	0.07	0.06	0.08	0.06	0.06
Extraction L-4s (Edgewise)								
Mean	0.14	—	—	0.10	0.02	-0.09	0.12	0.12
S. D.	0.45	—	—	0.47	0.35	0.52	0.45	0.39
S. E.m	0.07	—	—	0.06	0.05	0.07	0.06	0.05
Extraction L-5s (Edgewise)								
Mean	0.32	0.23	0.09	—	—	0.02	0.22	-0.07
S. D.	0.48	0.70	0.50	—	—	0.49	0.50	0.39
S. E.m	0.13	0.20	0.11	—	—	0.10	0.13	0.09
Extraction L-4s (Begg)								
Mean	0.18	—	—	0.38	0.22	0.33	0.29	0.23
S. D.	0.17	—	—	0.27	0.27	0.25	0.17	0.36
S. E.m	0.05	—	—	0.07	0.06	0.06	0.04	0.08

TABLE VI

	Extrusion of 2 MM or More				*No Change In Tooth Level*			
Area	M	D	M	D	M	D	M	D
Measured	U-5,6	U-3,5,6	U-5,6	U-3,5,6	U-5,6	U-3,5,6	U-5,6	U-3,5,6
Change in Height of Alveolar Bone Proper	.36	.12	.06	.25	.26	.08	.17	.18
Number of Teeth	15	20	23	26	16	25	9	17
Range of Extrusion	2to7	2to7	2to5	2to5	0	0	0	0
Mean Extrusion	2.75	3.12	2.84	2.91	0	0	0	0

tipping of cuspids in the first stage of Begg technique, followed by uprighting of the roots, had no different effect on the alveolar bone proper at point Z than did the conventional edgewise management of the cuspids.

The effect of extrusion of the teeth on the relationship of point Z to the cemento-enamel junction was investigated. Twenty-eight cases were selected in which the teeth exhibited two millimeters or more of extrusion. The amount of extrusion of the teeth was determined by measurements from before and after treatment cephalometric headfilms. Measurements were made on tracings from the palatal plane or mandibular plane to the occlusal surface of the respective tooth. A control group which showed no change in tooth height was selected from the same tracings. The range and mean of extrusion of the teeth are shown on Table VI. The mean change in the relationship of point Z to the cemento-enamel junction of these teeth was measured from the intraoral bitewing roentgenographs and recorded in Table VI.

There is no significant amount of bone loss (less than 0.5 mm) in any of the areas of extruded teeth. The "t" test proved no difference between extruded or nonextruded tooth areas. Therefore, it is shown that the relationship of alveolar bone to cemento-enamel junction remains constant when teeth are extruded. The bone follows the tooth.

Conclusions

1. The relationship of the alveolar bone proper at point Z to the cemento-enamel junction at the mesial and distal of the teeth in the intraoral bitewing roentgenograph can be measured to the nearest 0.5 mm.

2. The measurement of the distance of point Z to the cemento-enamel junction for the sample group of children studied was found to range between a mean of 0.11 mm and 0.84 mm in the bone areas. A standard deviation of less than 0.84 mm in all areas was found.

A table of means of the relationship between the alveolar bone proper at point Z and the cemento-enamel junction is presented for the mesial and distal of teeth in the buccal segments.

3. A slight general decrease in the height of the alveolar bone proper of *less* than 0.5 mm was observed following orthodontic treatment. Could this be a normal two-year change in children ten to sixteen years of age?

4. There was no significant difference in the change of the height of point Z to the cemento-enamel junction between the nonextraction cases and cases in which first bicuspids had been extracted, or between first bicuspid extraction cases treated by edgewise appliance or Begg appliance.

5. Moving teeth toward an extraction area had no specific effect upon the alveolar bone proper at point Z.

6. Extrusion of teeth during orthodontic treatment had no specific effect upon the alveolar bone proper at point Z. The bone appeared to follow the tooth, and a constant relationship between the height of the alveolar bone proper and the cemento-enamel junction was maintained.

7. It is concluded that, in children in good health, the alveolar bone proper at point Z follows the tooth as it is moved mesiodistally or occlusally in orthodontic treatment, thereby maintaining a constant relationship between point Z and the cemento-enamel junction. It is also recorded that this constant relationship is maintained both through bodily movement as well as tipping movement of teeth.

2001 State Tower Bldg.

BIBLIOGRAPHY

1. Beube, F. E., A Study on Reattachment of the Supporting Structures of the Teeth, *J. Periodont.*, 18:55-66, 1947.
2. ————., Radiographic and Histologic Study in Reattachment, *J. Periodont.*, 23. 158-164, 1952.
3. Buchner, J. J., An Answer to Some Criticisms of Treatment following Bicuspid Extractions, *Angle Orthodont.*, 14:23-47, 1949.
4. Eggers, Lura H., Tissue Reactions of Bone Upon Mechanical Stresses, *Am. J. Orthodont.* 38:453-459, 1952.
5. Glickman, I., Effect of Acute Starvation upon the Apposition of Alveolar Bone Associated with Extraction of Functional Antagonists, *J. D. R.*, 24:155-160, 1945.
6. ————., Interrelation of Local and Systemic Factors in Periodontal Disease: Bone Factor Concept, *J. A. D. A.*, 45:422-429, 1952.
7. Glickman, S., Adaptability of Alveolar Bone, *Tufts Dental Outlook*, 22:20-22, 1948.
8. Gottlieb, B., Some Orthodontic Problems in Histologic Illumination, *Am. J. Orthodont. and Oral Surg.*, 32:113-133, 1946.
9. Gottlieb, B., et al., Biology and Pathology of the Tooth and Its Supporting Mechanism, New York: *The Macmillan Company*, 1938, 54 pp.
10. Halderson, H. et al., The Selection of Forces for Tooth Movement, *Am. J. Orthodont.*, 39:25-35, 1953.
11. Huettner, R. J. & Whitman, C. C., Tissue Changes Occurring in the Macaque Monkey During Orthodontic Movement, *Am. J. Orthodont.*, 44: 328-345, May 1958.
12. Massler, M., Changes in the Lamina Dura During Tooth Movement, *Am. J. Orthodont.*, 40:364-372, May 1959.
13. McLean, F. C., Symposium on Bone and Bone Resorption, *J. Periodont.*, 25:70-72 January 1954.
14. ————, Biochemical and Biomechanical Aspects of Bone Resorption, *J. Periodont.* 25:176-182, July 1954.
15. Moyers, Robert E., The Periodontal Membrane in Orthodontics, *J. A. D. A.*, 40:22-27, 1950.
16. Moyers, R. E. and Bauer, J. L., The Periodontal Response to Various Tooth Movements, *A. J. of Orthodont.*, 36: 572-580.
17. Oppenheim, A., Biologic Orthodontic Treatment and Reality, *Angle Orthodont.*, 5 & 6: 1935-1936.
18. ————, Crisis in Orthodontia, *Int. J. Orthodont.*, 13-21: 1933-1935.
19. ————, Human Tissue Response to Orthodontic Intervention of Short and Long Duration, *Am. J. Orthodont. and Oral Surg.*, 28:263-381, 1942.
20. ————, Possibility for Physiologic Orthodontic Movement, *Am. J. Orthodont. and Oral Surg.*, 30:277-328, 1944.
21. Orban, B., Oral Histology and Embryology, St. Louis, Mo.: *C. V. Mosby Company*, 1953. 176-192 pp.
22. Pollia, J. A., *The Fundamental Principles of Alveolo-Dental Radiology*, Brooklyn, N. Y.: Dental Items of Interest Publishing Co., 1930, 186-227 pp.
23. Reitan, K., The Initial Tissue Reactions Incident to Orthodontic Tooth Movement, *Acta Odont. Scandinav.* Supp. G, Oslo 1951.
24. ————, Tissue Reaction in Relation to the Age Factor, *Dental Record*, 74:271-278, October 1954.
25. ————, Bone Factors Determining the Evaluation of Forces in Orthodontics, *Am. J. Orthodont.*, 43:32-45 January 1957.
26. ————, Tissue Behavior During Orthodontic Tooth Movement, *Am.*

J. Orthodont., 46:881-900 December 1960.

27. ———, Bone Formation and Resorption During Reverse Tooth Movement, *Vistas in Orthodontics*, Kraus, B. S. and Riedel, R. A., Lea & Febiger, Philadelphia 1962.
28. Ritchey, B. and Orban, B., The Crests of the Interdental Alveolar Septa, *J. Periodont.*, 24:75-83, 1953.
29. ———, Crests of the Interdental Alveolar Septa, *Radiog. and Photog.*, 27:37-42, 54-56, November 3, 1954.
30. Simpson, Clarence O., *Advanced Radiodontic Interpretation* (third edition) St. Louis, Mo.: C. V. Mosby Company, 1947 47-52 pp.
31. Skillan, G. and Reitan, K., Tissue Changes Following Rotation of Teeth in Dogs, *Angle Orthodont.* 10:140-147, 1940.
32. Smith, H. W., Alveolar Bone Regeneration, *Oral Surg., Oral Med. and Oral Path.*, 5:117-132, 225-240, 1952.
33. Stahl, S. S., The Influence of Systemic Disease on Alveolar Bone, *J.A.D.A.*, 45:277-283, 1952.
34. Storey, Elsdon, Bone Changes Associated with Tooth Movement, A Radiographic Study, *Austral. J. Dent.*, 57:57-64, 1953.
35. Stuteville, O. H., A Summary Review of Tissue Changes Incident to Tooth Movement, *Angle Orthodont.*, 8:1-20, 1938.
36. ———, Injuries to the Teeth and Supporting Structures Caused by Various Orthodontic Appliances and Methods of Preventing These Injuries, *J. A. D. A.*, 24:1494-1507, 1937.
37. Weinmann, J. P., Bone Changes Related to Eruption of Teeth, *Angle Orthodont.*, 11:83-99, 1941.
38. Weinmann, F. P. and Sicher, H., *Bone and Bones* St. Louis, Mo.,: The C. V. Mosby Company 1947, 121-184 pp.