

APICAL ROOT RESORPTION AFTER ORTHODONTIC THERAPY: A QUALITATIVE  
ROENTGENOGRAPHIC COMPARISON OF THE EDGEWISE  
AND THE BEGG LIGHTWIRE TECHNIQUES

by

RUSSELL DANIEL BULCHAK

Submitted in partial fulfillment of the requirements  
for the Degree of Master of Science

Department of Orthodontics  
WESTERN RESERVE UNIVERSITY

June 1964

Dentistry

377.771

08933

6-1-64

RULES COVERING USE OF MANUSCRIPT THESES IN THE  
WESTERN RESERVE UNIVERSITY LIBRARIES

Unpublished theses submitted for the doctor's degrees and deposited in the Western Reserve University Libraries are open for inspection, but are to be used only with due regard to the rights of the authors. For this reason it is necessary to require that a manuscript thesis be read within the Library. If the thesis is borrowed by another Library, the same rules should be observed by it. Bibliographical references may be noted, but passages may be copied only with the permission of the authors, and proper credit must be given in subsequent written or published work. Extensive copying or publications of the thesis in whole or in part must have the consent of the author as well as of the Dean of the Graduate School.

This thesis by.....  
has been used by the following persons, whose signatures attest their acceptance of the above restrictions.

A Library which borrows this thesis for use by its readers is expected to secure the signature of each user.

---

---

NAME AND ADDRESS

DATE

WESTERN RESERVE UNIVERSITY  
THE GRADUATE SCHOOL

We hereby approve the thesis of

Russell Daniel Bulchak

candidate for the Master of Science degree.

Signed:

Richard C. Beatty, D.D.S., V.A.C.D.  
Chairman

Date

April 29, 1964

#### ACKNOWLEDGMENTS

The author wishes to express his sincere gratitude to Dr. Sanford Neuger, Assistant Professor of Orthodontics, Department of Orthodontics, Western Reserve University, whose assistance in obtaining the necessary records and in the preparation of this paper was of inestimable value.

He also desires to express his thanks to Dr. Richard C. Beatty, Chairman of the Orthodontic Department, and Dr. Philip Burwasser, Director of Post Graduate Studies, Western Reserve University School of Dentistry, for their cooperation and suggestions.

A debt of gratitude is also owed Dr. Norman B. Rushforth for his assistance with the statistical analysis of the material collected in this study.



### **DEDICATION**

To the author's wife and parents, for their patience,  
understanding and encouragement.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS . . . . .	ii
DEDICATION . . . . .	iii
LIST OF TABLES . . . . .	v
LIST OF ILLUSTRATIONS . . . . .	vi
INTRODUCTION . . . . .	1
Chapter	
I. REVIEW OF THE LITERATURE . . . . .	3
II. METHODS AND MATERIALS . . . . .	11
III. FINDINGS . . . . .	16
IV. DISCUSSION . . . . .	21
V. SUMMARY AND CONCLUSIONS . . . . .	25
BIBLIOGRAPHY . . . . .	30

## LIST OF TABLES

Table	Page
1. Degree of Root Loss before and after Treatment Using the Two Different Techniques . . . . .	16
2. Coefficient of Correlation between Observers . . . . .	18
3. Analysis of Variance Table . . . . .	20
4. Mean Changes in Root Loss with Varying Types of Tooth Movement . . . . .	20
5. Comparison of Incidence of Root Loss after Treat- ment . . . . .	22
6. "t" Test for Age at Inception of Treatment . . . . .	26
7. "t" Test for Duration of Treatment . . . . .	27
8. Evaluations of Root Loss before and after Treatment with Begg Technique . . . . .	28
9. Evaluations of Root Loss before and after Treatment with Edgewise Technique . . . . .	29

## LIST OF ILLUSTRATIONS

Figure	Page
1. 0 - No Evidence of Root Resorption . . . . .	12
2. 1 - Slight or Minimal Root Loss . . . . .	12
3. 2 - Moderate Root Loss . . . . .	12
4. 3 - Severe Root Loss . . . . .	12
5. Apical Tipping . . . . .	15
6. Anterior or Posterior Apical Displacement . . . . .	15
7. Lingual Bodily Movement . . . . .	15

## INTRODUCTION

Over the years, the problem of root resorption has interested many investigators. The early investigators viewed root resorption with trepidation, as it was felt that the life and function of the dental units would be endangered. The orthodontist became greatly concerned when it was first shown that tooth movement caused root resorption. However, a survey of the more recent publications shows most orthodontists are convinced that with proper handling of appliances and control of forces, the amount of root loss during treatment can be considered as not detrimental to the life span or function of the dental units.

Apical root loss or resorption of permanent teeth is herein defined as an irreparable shortening of root length of teeth. This is in contradistinction to "cementum resorption" which occurs on all sides of the tooth root and is readily repaired."<sup>1</sup>

Massler and Malone<sup>2</sup> demonstrated that a definite resorptive potential was present in the permanent teeth of all people. This resorptive potential varied in different individuals, and also in different teeth of the same individual. The incidence and severity of the resorptions increased markedly in those individuals who were treated orthodontically.

Hemley<sup>3</sup> contended that lingual bodily movement of the apices of the teeth through bone predisposed to apical root resorption. One

of the criticisms of the Edgewise technique was the use of strong torque forces on the anterior teeth in order to attain this lingual bodily movement of the apices. This criticism was thoroughly disproved in an excellent study by Phillips.<sup>4</sup> He showed that there was no statistically significant difference in the amount of root loss created by the various methods of tooth movement, i.e., apical tipping, anterior or posterior apical displacement, or lingual bodily movement.

Recently, Begg<sup>5, 6, 7</sup> introduced a new differential light force treatment technique. Storey and Smith<sup>8</sup> provided the initial important substantiation of the biomechanics involved in this new treatment concept. Begg's technique as well as various modifications of it are steadily gaining acceptance in North America. Many unsubstantiated statements have been made regarding a decrease in the incidence and severity of apical root loss of permanent teeth treated by these newer techniques.<sup>9, 10</sup>

The purpose of this study is to determine whether there is a clinically practical or a statistically significant difference in the amount of root resorption after orthodontic treatment of patients under one of two different treatment techniques, that is the Edgewise technique as opposed to the Begg lightwire technique.



## I. REVIEW OF THE LITERATURE

Root resorption has been recognized and discussed as a problem of consequence by the dental profession for over a century. According to Henry and Weinmann<sup>1</sup>, the resorption of permanent teeth was first mentioned in the literature by Bates in 1856. Bates attributed the cause to the traumatization of the periodontal membrane. This report was followed by the publication of numerous case reports, describing primarily the most severe and bizarre forms of root resorption.

Root resorption in the deciduous dentition is a normal phenomenon. It is generally accepted that one of the important factors responsible for the resorption of the deciduous roots is the presence of the succedaneous tooth. However, root resorption of a deciduous tooth may occur when a permanent successor is absent.<sup>11</sup>

Resorption of permanent teeth results from trauma, infection or inflammation, systemic disturbances, pressure and mechanical forces such as orthodontic tooth movement.<sup>12, 13</sup>

Orthodontically created root resorptions were first reported in the literature by Ottolengui in 1914.<sup>14</sup> Little attention was accorded this report until Ketcham<sup>15</sup> startled the dental profession in 1926, with reports of his radiographic survey of 385 treated cases from his own orthodontic practice. Ketcham indicated that twenty-one per cent of the patients examined roentgenographically after treatment showed evidence of root resorption of the anterior permanent teeth.



He found that the maxillary teeth were more predisposed to root resorption than the mandibular teeth. In his 1929 study<sup>16</sup> he reported that resorption occurred in only one per cent of a sample made up of persons who had not been orthodontically treated. Ketcham thought that something more than faulty manipulation was responsible for this problem and named the predisposing susceptibility of individual patients, diet, and faulty metabolism as prime factors to be considered. He also suggested that the life and function of the teeth with resorbed roots might be impaired.

Massler and Malone's critique of Ketcham's findings was well taken. They stated,

It was fairly certain that Ketcham reported only the instances of very obvious resorption as evidenced by marked foreshortening of the roots. It might also be noted that radiographic techniques were not yet standardized at that time, so that well angulated, undistorted, and clear films such as are routinely available today were a rarity in 1929.

Nevertheless, Ketcham's reports were a catalyst. They challenged the orthodontist to review his own experience, and stimulated not only further roentgenographic studies, but also investigations of the whole physiological process of tooth movement on experimental animals and human patients.

Marshall<sup>13, 17, 18, 19</sup> presented evidence of increased resorption of the teeth of macaca rhesus monkeys fed restrictive diets. There has been no further substantiation of his findings.

In 1936, Rudolph<sup>20, 21</sup> found the incidence of root resorption to be as high as seventy-four per cent during or following orthodontic treatment. In a later study he found evidence of root resorption in

all orthodontically treated permanent teeth. His untreated control group had a frequency of only five per cent root resorption. Rudolph suggested that treatment is less hazardous to root structure when it is initiated at an earlier age and that the younger the patient at the onset of treatment, the more prolonged the treatment could be without permanent root loss. Fischer<sup>22</sup> supported this view. Both men advocated early treatment in the mixed dentition stage. There is still some question as to whether or not the roots of teeth without fully formed apices will develop to their full potential length when subjected to orthodontic treatment. There is histological evidence that these views regarding early treatment may be untenable. Johnson, Appleton, and Rittershofer<sup>23</sup>, and Gottlieb and Orban<sup>24</sup> reporting their experiments on monkeys noted apical deformities when orthodontic forces were applied to young forming permanent teeth (incomplete root formation). Oppenheim<sup>25</sup> corroborated these animal experiments with human material, showing deformation of the completed root tip. Kronfeld believed blunted or shortened root ends following orthodontic treatment of teeth to be due either to resorption at the apex or to a deformity and distortion of Hertwig's sheath, if the tooth was moved before root formation is completed.

Becks<sup>12, 26, 27</sup> showed that regardless of the duration of orthodontic forces used in treatment, certain patients showed a greater predisposition to root resorption. He also stated that those children who show a tendency to root resorption prior to treatment are poor orthodontic risks. Becks felt that metabolic disturbances such as



endocrine imbalance are active factors in root resorption. Of 100 patients with roentgenographically obvious root resorption, fifty treated orthodontically and fifty untreated, he found on twenty per cent of the treated group incurred root resorptions due to mechanical trauma incident to tooth movement. The remainder of the resorptions he believed to be caused by systemic factors as diagnosed by changes in other osseous structures. Becks was the first to classify the degree of root resorption by dividing the root into thirds and referring to Class I, Class II, Class III resorptions depending on which third the resorption involved; Class I being apical and class III being cervical. He was one of the first investigators to note that moderate root loss was clinically insignificant unless accompanied by a concomitant bone loss at the alveolar crest.

It has been reported elsewhere that Becks' diagnostic procedures for determining the presence of endocrinopathies were insufficient and inconclusive.<sup>2, 4</sup>

Schwarz<sup>28</sup>, Orban<sup>29</sup>, Oppenheim<sup>25, 30, 31</sup>, and Stuteville<sup>32, 32</sup> all of whom contributed much to the understanding of the physiological process of tooth movement during the period 1929 to 1942, endorsed the theory that root loss was caused by excessive orthodontic forces. Hemley<sup>3</sup> believed that the moving of teeth horizontally through bone had a tendency to cause apical root loss. Modifications of his classification of the degrees of root resorption has been accepted as the method of choice in the studies of the more recent investigators. Oppenheim<sup>31</sup> felt that the shape of the roots of the anterior maxillary teeth in particular predisposed them to apical root loss. He further

stated that damage to the root surface would occur no matter how slight the forces used. Schour<sup>34</sup> suggested that the genetic endowment may be a factor in root resorption.

Henry and Weinmann<sup>1</sup> found that 76.8 per cent of the 261 teeth they examined histologically showed areas of root resorption. Contrary to previous views, inflammation per se, did not cause root resorption. Mechanical irritation or trauma appeared to be the most important local factor in the production of resorption. They also stated that the relatively small areas of resorption could under ideal conditions be recognized in the radiograph.

Massler and Malone<sup>2</sup> state, "There appears to be an inherent predisposition for the roots of all teeth, permanent as well as primary, to incur resorptions, albeit to greatly varying degrees." They examined radiographically 708 individuals, none of whom had been orthodontically treated. Their ages ranged from twelve to forty-nine years. One hundred per cent of this untreated sample showed some evidence of periapical resorption in one or more permanent tooth roots. Of the 13,263 untreated teeth examined, 86.4 per cent showed some evidence of resorption; 1.6 per cent revealed no resorption and the remaining twelve per cent fell into the questionable category. There were no statistically significant sex differences in the amount of root loss. The resorptive pattern was strongly bilateral. The causative factors of five per cent of the root resorptions were determined to be due to periapical infection and root canal therapy. The remaining resorptions were of unknown etiology, the so called idiopathic resorption. Of the 81.2 per cent of the idiopathic resorptions, ten per cent showed at least a



moderate degree of resorption.

The authors then compared the incidence and severity of root resorption found in eighty-one orthodontically treated cases with the untreated group. Of the 2,085 orthodontically treated teeth, 93.3 per cent showed evidence of root resorption, 6.7 per cent were questionable. No teeth were found that could be recognized as having no resorption. The frequency of moderate resorptions rose from 9.2 per cent in the untreated group to 31.4 per cent in the orthodontically treated group. Severe resorptions increased from 0.4 per cent in the control group to 14.2 per cent in the test group.

Analysis revealed that those teeth which showed low or questionable resorptive activity prior to treatment were apparently "stimulated" by orthodontic procedures to show definite but mild resorption. Those teeth which originally showed mild resorption were more severely resorbed under the influence of orthodontic mechanical stresses.

Though there was no significant change in the frequency of mild resorptions experienced with increased age, Massler and Malone did find a significant increase in the frequency of the more severe forms of resorption with age. They also concurred with the findings of others that the anterior teeth are most susceptible to root resorption due to orthodontic treatment.

It is our view that Massler and Malone erred somewhat in their comparison with the two groups under study. Their untreated control group ranged in age from twelve to forty-nine years, while the orthodontically treated group ranged from twelve to nineteen years of age. Since there is an increased amount of severe root loss with increasing

age<sup>1, 2</sup> these two groups cannot be considered comparable because of the differing age distributions of the subjects.

In 1955, Phillips<sup>4</sup> studied the effects of treatment with the continuous Edgewise appliance on the permanent teeth with regard to root loss. He found that of the total 1745 teeth examined after orthodontic treatment, 61.1 per cent showed no root loss, 7.4 per cent were in the questionable class, 26.8 per cent showed slight root resorption, 4.3 per cent were in the moderate category and 0.3 per cent were classified as being excessively resorbed.

Of the teeth which showed definite signs of root resorption, the maxillary centrals and laterals demonstrated the greatest predisposition to root loss, primarily in the moderate and severe classes. It was also found that root loss showed a strong tendency to be bilaterally symmetrical. These findings were similar to those of Massler and Malone. Phillips further demonstrated, as Massler and Malone had done previously that there were no significant sex differences in apical root loss. He also showed that the age of the patient at the inception of treatment had no correlation to the amount of apical root loss. Furthermore, he was unable to demonstrate any correlation between the amount of root loss and the length of treatment. These findings were in strong disagreement with those of Rudolph.

Probably the most significant finding was that no correlation was demonstrated between the amount of root loss and the amount and type of tooth movement through bone. This disproved Hemley's idea that bodily movement of teeth horizontally through bone created the greatest amount of resorption at the apices.

It would appear that root resorption is a fairly common dental lesion. The following statements seem to represent a fair summary of the literature on this subject to date:

1. There appears to be strong evidence of an inherent predisposition to root resorption in all individuals.
2. This resorptive potential varies in different individuals.
3. Maxillary central and lateral incisors appear to be most susceptible to root loss, particularly incident to orthodontic treatment.
4. There are no sex differences apparent in the incidence of severity of root resorption.
5. Apical root loss shows a strong tendency to be bilaterally symmetrical.
6. There appears to be a significant increase in the severity of root resorption with increase in age.

With the above six statements as basic assumptions, a series of intra-oral x-rays was used to determine the amount of root loss in patients treated by two different orthodontic techniques. For convenience, only the right maxillary central incisors were included in this study.



## II. METHODS AND MATERIALS

Before and after treatment intra-oral x-rays of the right maxillary central incisors which were taken by the referring general practitioner were obtained and examined in a manner similar to the methods of Hemley<sup>3</sup>, Becks and Cowden<sup>28</sup>, and Phillips.<sup>4</sup> Lateral cephalometric head films were used to determine the types of tooth movement (apical tipping, anterior or posterior apical displacement and lingual bodily movements) found to occur in the maxillary central incisors. The treatment records of the patients were searched and from them we obtained the following information:

- (i) sex of the patient
- (ii) age of the patient at the start of treatment
- (iii) duration of treatment

### (I) Before and After Treatment Intra- Oral X-rays of the Patients

Forty sets of before treatment and after treatment intra-oral x-rays of the maxillary central incisors were used. Twenty cases were patients living in Cleveland, Ohio; and were treated by the Edgewise technique in the private practice of a member of the faculty of the department of Orthodontics. The other twenty cases were of patients from Canton, Ohio. They were treated by the Begg technique. These records were obtained from the private practice of an orthodontist not affiliated with the dental faculty.

Illustrations of the Various Degrees of Root Loss

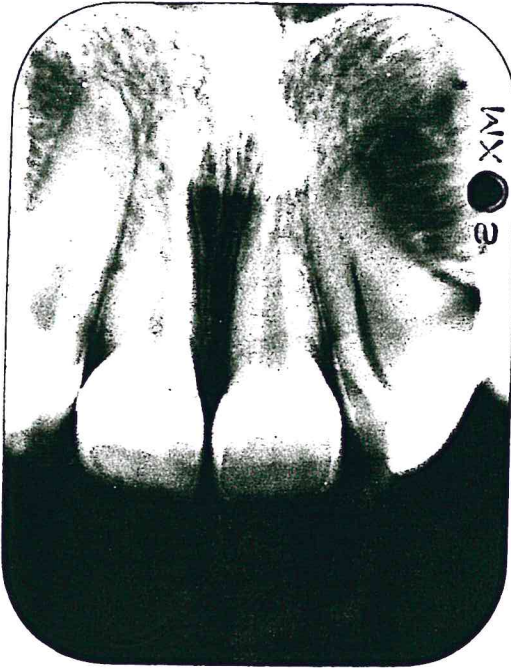


Fig. 1.--0 - no evidence of root resorption.

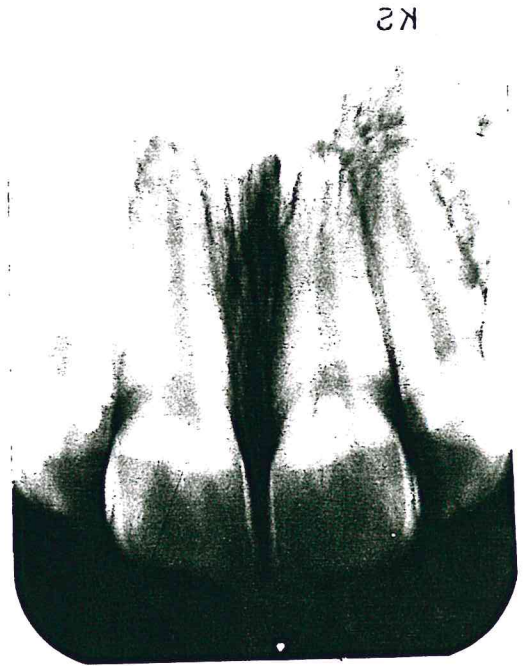


Fig. 2.--1 - slight or minimal root loss.

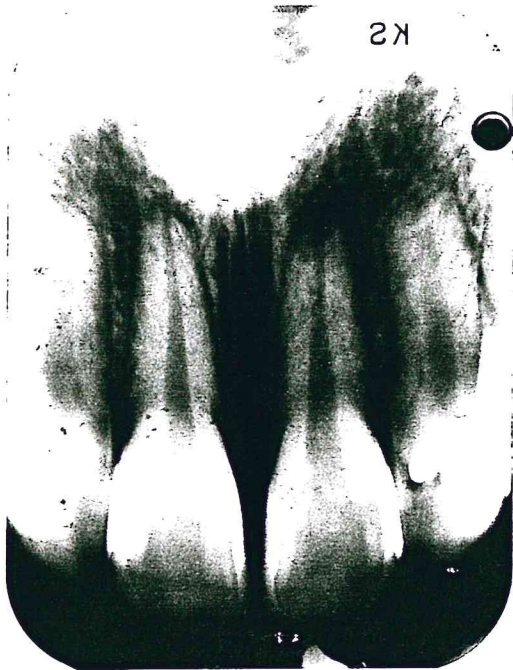


Fig. 3.--2 - moderate root loss.



Fig. 4.-- 3 - severe root loss.



The forty patients composing the two sample groups were all Caucasian children. The Edgewise group was composed of thirteen females and seven males, while the Begg group was composed of fourteen females and six males. All cases were "full treatment" cases, each treated by the appliance of choice in the generally accepted manner as outlined for that particular technique. The total number of teeth examined was eighty. Of the twenty Edgewise cases, fifteen were extraction cases; fourteen of which had four bicuspids extracted, and the fifteenth was a case in which the four first permanent molars were extracted by a general practitioner just prior to the patient presenting himself for treatment. Of the twenty cases treated by the Begg technique eighteen patients had teeth extracted; seventeen had four bicuspids removed and one had two maxillary first bicuspids extracted. No mixed dentition cases were included in this study.

A data chart was set up providing a space for recording the evaluation of each maxillary central incisor after inspection, using the following criteria to estimate and score the amount of apical root loss:

- 0 - no evidence of resorption
- 1 - slight; minimal blunting of the root apices
- 2 - moderate; up to approximately one-fourth root length loss
- 3 - severe; more than one-fourth root length loss.

The questionable category as used by Massler and Malone<sup>2</sup> and Phillips<sup>4</sup> was not used since a classification into none, minimal, moderate and severe was thought to be reasonably clear, and is borne out by the degree of agreement among the three observers who independently

scored the cases.

The dividing line between the various categories, particularly between the slight and moderate classes was difficult to differentiate in some cases because of distortions (foreshortening or elongation) due to film placement, differences in x-ray cone angulation, and variation of x-ray technique by different operators. Because of this difficulty and in order to make the study as objective as possible, the films were scored separately by the three individuals and compared only after all opinions had been tabulated. The films were randomly placed into coded envelopes such that the investigators had no knowledge of the source or status of the film. Inspection of the films was done by a member of the orthodontic staff and two graduate students in orthodontics. In the event of differences in evaluation of the amount of root loss, the assessment of that tooth was placed in the category of majority opinion. (See Tables 8 and 9).

The before and after treatment evaluations of root loss were subjected to the "t" test. These tests were done to determine:

- (i) if the degree of root loss was equivalent in the two groups before treatment,
- (ii) whether any significant differences in the amount of root loss were created by treatment with the two varying techniques.

## II. Use of the Lateral Head Plate

Before and after oriented lateral head plates of the forty patients involved in this study were obtained, Cephalometric tracings were made in each case of the maxillary central incisor and the associated bony structures, including the outlines of the hard palate, floor

of the nose and the anterior nasal spine. These tracings were then superimposed according to accepted methods<sup>35, 4</sup> to show the direction or type of movement of the traced maxillary central incisor.

A statistical analysis was made to determine whether the effect of the various tooth movements on the degree of root loss was significant.

### Types of Tooth Movement

(The following descriptions of the types of tooth movement were obtained from Phillips' paper<sup>4</sup> in the Angle Orthodontist, XXV, No. 1, 1955.)

1. Apical tipping--the apex stayed in its original position or was extruded slightly during treatment but remained in the same plane. (Figure 5.)

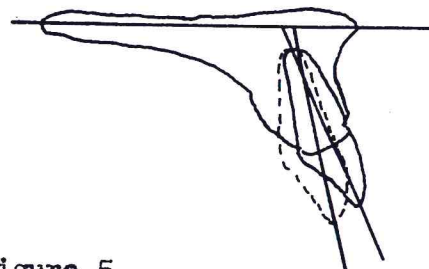


Figure 5.

2. Anterior or posterior apical displacement. The apex moved in a horizontal direction, anteriorly or posteriorly. (Figure 6).

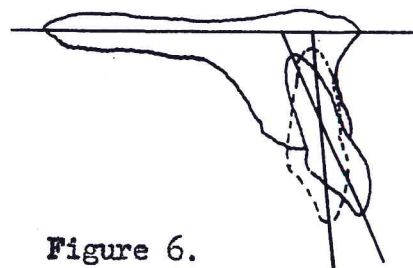


Figure 6.

3. Lingual bodily movement--Bodily movement of the teeth lingually from their original position. (Figure 7.)

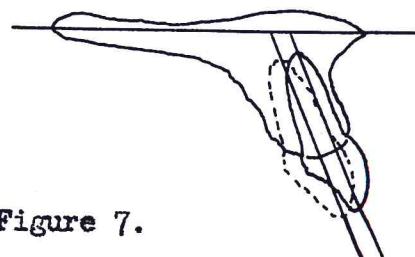


Figure 7.



### III. FINDINGS

The results from inspection of the intra-oral x-rays and determination of the type of tooth movement for each patient in the two groups studied are shown in Tables 8 and 9.

1. A total of eighty maxillary right central incisors were inspected, categorized and tabulated--twenty before and after intra-oral films for each of the two different techniques, that is the Edgewise and the Begg appliances.

TABLE 1  
DEGREE OF ROOT LOSS BEFORE AND AFTER TREATMENT  
USING THE TWO DIFFERENT TECHNIQUES

	Edgewise Group		Begg Group	
	Before	After	Before	After
No resorption	65%	10%	60%	0%
Minimal resorption	35	45	35	60
Moderate resorption	0	45	5	35
Severe resorption	0	0	0	5

Before treatment with the Edgewise appliance, sixty-five per cent of the incisors showed no resorption and thirty-five per cent demonstrated only minimal blunting. There were no cases of moderate or severe resorptions. After treatment only ten per cent of the teeth were observed to have no resorption, forty-five per cent were minimally resorbed and the remaining forty-five per cent were moderately resorbed.

Before treatment with the Begg technique sixty per cent of the

incisors showed no resorption, thirty-five per cent showed minimal root loss and five per cent demonstrated moderate resorption. Three of the twenty cases in this sample were retreatment cases. After treatment 100 per cent of the incisors demonstrated definite evidence of some degree of root loss. Sixty per cent showed minimal blunting, thirty-five per cent were moderately resorbed and five per cent showed severe resorption. This last case was one of the retreated cases.

The "t" test was used to find if the two groups were comparable with regard to:

- (i) age of the patients at the inception of treatment. (Table 6.)
- (ii) duration of treatment. (Table 7.)
- (iii) the degree of root loss at the start of treatment.

2. Age of the patients at the inception of treatment.

Edgewise group.--The age range was from 118 to 208.5 months with a mean of 156.67 months and a standard deviation of 19.03 months.

Begg group.--The age range was from 132 to 205 months with a mean of 160.37 months and a standard deviation of 18.32 months.

The observed "t" value (0.62) shows no significant difference at the five per cent level with thirty-eight degrees of freedom. Therefore the two groups are comparable for age.

3. Duration of treatment.

Edgewise group.--Duration of treatment ranged from thirteen to 31.5 months with a mean of 22.15 months and a standard deviation of 4.64 months.

Begg group.--Duration ranged from 11.5 to 30.75 months with a



mean of 19.65 months and a standard deviation of 4.43 months.

The observed "t" value (1.74) showed no significant difference between the two groups at the five per cent level with thirty-eight degrees of freedom. These two groups are therefore equivalent with respect to duration.

#### 4. Test for Agreement between the Three Observers' Evaluations.

All three observers were in complete agreement in the evaluation of fifty of the eighty determinations. Two were in agreement in the remaining thirty cases.

The data was analyzed statistically and the coefficients of correlation obtained to determine the measure of accuracy among the three observers in evaluating the degree of root loss.

TABLE 2  
COEFFICIENT OF CORRELATION BETWEEN OBSERVERS

#1 - #2	#2 - #3	#1 - #3
$r_1 = 0.76$	$r_2 = 0.75$	$r_3 = 0.73$

P .01 for each of these tests that there is no association between ratings. Thus a reliable measure of agreement and accuracy exists among the three judges.

#### 5. Test for Differences in Degree of Root Loss between the Two Groups at the Start of Treatment.

The observed "t" value (0.59) again demonstrates no significant differences between the two groups at the five per cent level with

thirty-eight degrees of freedom. Therefore the severity of root loss is equivalent in the two groups.

6. "t" Test for differences in the Severity of Root Loss at the End of Treatment.

The observed "t" value is  $\frac{0}{.0526}$  which equals 0. It is not significant at the five per cent level with thirty-eight degrees of freedom. Therefore there is no clinically practical or statistically significant difference between the two treatments with regard to apical root loss.

7. Test for Differences in the Severity of apical Root Loss between the Before and After Treatment Condition for Each of the Techniques.

Edgewise sample.--The observed "t" for differences in apical root loss between the before and after evaluations equals 5.62 and is significant at the 0.1 per cent level with nineteen degrees of freedom.

Begg sample.--The observed "t" is 6.9 and is significant at the 0.1 per cent level with nineteen degrees of freedom.

This indicates that there is a very significant increase in the severity of root resorption after orthodontic treatment using both treatment techniques.

8. In order to determine if the different types of tooth movement (apical tipping, lingual bodily and anterior or posterior apical displacement) caused significantly different root losses, the two groups were pooled and an analysis of variance was performed on the changes in root loss. In our pooled sample, eleven cases demonstrated apical tipping, sixteen cases showed lingual bodily movement and the remaining

thirteen cases were observed to have anterior or posterior apical displacement. The analysis of variance table is presented below together with mean changes in root loss for the three types of tooth movement.

TABLE 3  
ANALYSIS OF VARIANCE TABLE

Source of Variance	Sums of Squares	Degrees of Freedom	Mean Squares	F
Between movements	2.66	2	1.33	2.84
Within movements	17.34	37	.468	P .05
	20.00	39	not significant at 5% level	

It is evident that there is no significant difference between the types of movement in the production of root loss. (See Table 3.)

TABLE 4  
MEAN CHANGES IN ROOT LOSS WITH VARYING  
TYPES OF TOOTH MOVEMENTS

Apical tipping	Lingual bodily	A - P Displacement
$\bar{x}_1 = 1.27$ scoring units	$\bar{x}_2 = .69$ scoring units	$\bar{x}_3 = 1.15$ scoring units

Table 4 points out the interesting observation that, though there are no significant differences among the various types of movement in amount of root loss produced, tipping movement causes more mean root length loss than the other two types of tooth movement.



#### IV. DISCUSSION

Though the purpose of this study was primarily to find if differences existed in the severity of root loss created by orthodontic treatment using two different techniques, it was felt that it would not be improper to comment on certain other observations made in the course of collecting and analysing the data. The incidence of root resorption found in our pooled sample of forty cases before treatment was somewhat less than that observed by Massler and Malone. They found sixty-five per cent of the maxillary central incisors minimally resorbed, while 5.7 per cent demonstrated moderate resorption. We observed thirty-five per cent of the teeth minimally resorbed and 2.5 per cent had moderate root loss. This can be accounted for by the fact that Massler and Malone used binocular magnifying loupes in making their evaluations while we used only the naked eye. It was felt that any root loss which could not be seen by the naked eye had little clinical significance.

The after treatment observations of this study were found to lie between those of Massler and Malone and Phillips.

Table 5 points out certain variations as well as similarities. The variations reflect differences in evaluations by the three different groups. This is to be expected since the evaluations are qualitative and must perforce be classified as subjective since they are dependent on individual interpretation. Phillips defined slight

TABLE 5  
COMPARISON OF INCIDENCE OF ROOT LOSS AFTER TREATMENT

	Massler & Malone	Present Study	Phillips
No resorption	0%	5%	2.9%
Minimal resorption	12.4	52.5	62.3
Moderate resorption	44.3	40.0	20.3
Severe resorption	43.1	2.5	1.5

resorption as minimal blunting of the root apices. We found this to be rather vague. On the other hand, Massler and Malone referred to slight resorption as being a loss of root length in the amount of 1 to about 2 mm. This creates some difficulty for the observer. Even using an excellent intra-oral film it is difficult to gauge exactly whether the amount of root loss is 1.5 or 2.5 mm. by the means available at this time. The qualitative appraisal of a tooth which falls in the above category could be given a score of either one or two by the previously described scoring system. To further complicate the evaluations it must be admitted that not all of the intra-oral x-rays inspected in this study were of the excellent variety. Distortions of one type or another were observed. Still further, it must be remembered that the questionable category which Massler and Malone, and Phillips utilized was not used in this study. This would also tend to color the "0" and "1" categories. Despite these obvious limitations it was felt that they would balance each other out and that a valid result could be obtained. This is borne out by the high degree

of agreement among the three observers and the coefficients of correlation as discussed in the findings. It is felt that a further study of this problem should be done to quantify root loss by linear measurement. This can only be done as a long range study since the interval between the before and after treatment records statistically significant differences in the amount of root loss would be found between the various treatments.

Though root resorption is fairly common at the completion of orthodontic treatment, it is rarely of such a degree as to be of clinical significance. In this sample of forty cases, only in one instance (2.5 per cent) was the central incisor classified as being severely resorbed. In this particular case between one-fourth and one-half of the root length was lost, and this was one of the retreatment cases. Phillips found 1.5 per cent of the teeth examined severely resorbed. Becks<sup>27</sup>, Brodie<sup>36</sup>, and Tylman<sup>36</sup> felt that alveolar bone loss at the cervical root was more harmful to the retentive apparatus of a tooth than apical root loss, unless this root loss is severe. Tylman contends that a tooth may be used safely as an abutment for bridgework as long as its clinical root is greater than the clinical crown. Thus the loss of small amounts of bone at the alveolar crest will be clinically more significant than a similar loss of root structure.

It was also noted with some interest that apical tipping movements seemed to produce more root loss than either of the two other types of tooth movement. Though no significant differences existed in the amount of root loss between these various tooth movements, both our own as well as Phillips' findings showed greatest mean root loss



with apical tipping movements. This finding was somewhat surprising, since bodily movement is the most difficult to perform with any appliance and greater forces (torquing) are necessary to produce this movement. The question can now be raised--why should we be surprised to find that bodily movement is not the major transgressor in apical root loss? Is it possible that our preconceived ideas regarding orthodontically created root resorption are based on a hitherto unresolved guilt complex regarding the use of these strong torquing forces to produce bodily movement. I suspect that many of us who use the Edgewise appliance have a tendency to equate these strong torque forces with pressures which "stimulate" root resorption. It might do well for us to consider that though a torque force is greater, it is transmitted over a greater length and area of the root surface and may in effect produce less pressure per unit of area than that created by apical tipping movements. At any rate this somewhat surprising finding warrants further investigation.



## V. SUMMARY AND CONCLUSIONS

1. The two groups are comparable with regard to age at the start of treatment.
2. The two groups are equivalent with regard to duration of treatment.
3. A high degree of agreement in the evaluations of the amounts of apical root loss was demonstrated to exist between the three observers.
4. The two groups were comparable with regard to the amounts of root loss at the start of treatment.
5. No significant differences were found in the amount of root loss produced by the two different orthodontic treatment procedures. The amounts of root loss were equivalent between the Begg Lightwire Technique and the Edgewise Technique.
6. A very significant increase in the severity of root resorption was produced by orthodontic treatment regardless of the type of technique.
7. There were no significant differences in the amount of root loss with regard to various types of tooth movement.
8. Though the amount of apical root loss was not significantly different between types of movement, it was found that apical tipping movements produced the greatest amount of mean root length loss.

TABLE 6

"t" TEST FOR AGE AT INCEPTION OF TREATMENT

Edgewise Group	Begg Group
154.5 months	144.0 months
130.5	137.0
159.5	146.5
144.0	205.0
174.0	152.5
147.0	172.5
149.0	166.0
208.5	132.0
144.0	144.5
170.0	170.0
118.0	183.0
152.0	173.5
159.0	136.0
164.0	153.0
175.5	174.5
157.5	159.0
155.5	161.0
141.5	154.0
153.5	163.0
<u>176.0</u>	<u>180.5</u>

$$S_1 = 3133.5$$

$$S_2 = 3207.5$$

$$S.S._1 = 497,823.25$$

$$S.S._2 = 520,778.75$$

$$\bar{x}_1 = 156.67 \text{ mos.} \quad s_1^2 = 362.22 \text{ mos.} \quad \bar{x}_2 = 160.37 \quad s_2^2 = 335.57 \text{ mos.}^2$$

$$s_1 = 19.03 \text{ mos.}$$

$$s_2 = 18.32 \text{ mos.}$$

The observed "t" = 0.62 and is less than  $t_{.05, 38df} = 2.025$

Therefore the age of the patients at the inception of treatment in these two groups shows no statistically significant difference at the 5 per cent level with 38 degrees of freedom. The two groups may be compared.

TABLE 7

## "t" TEST FOR DURATION OF TREATMENT

Edgewise Group	Begg Group
23.0	20.5
21.0	14.25
25.5	17.0
17.0	25.0
14.75	16.25
24.75	11.5
24.0	17.5
18.5	18.5
27.0	21.0
22.25	20.75
18.75	16.5
31.5	22.5
21.75	19.5
21.5	20.25
24.5	16.75
21.0	24.75
26.0	22.5
13.0	30.75
18.25	22.75
<u>29.0</u>	<u>14.5</u>

$$S_1 = 443.0$$

$$S.S._1 = 10,221.125 \quad S_2 = 393.0 \quad S.S._2 = 8,095.25$$

$$\bar{x}_1 = 22.15 \text{ mos.}$$

$$\bar{x}_2 = 19.65 \text{ mos.}$$

$$s_1^2 = 21.50 \text{ mos.}^2$$

$$s_2^2 = 19.62 \text{ mos.}^2$$

$$s_1 = 4.64 \text{ mos.}$$

$$s_2 = 4.43 \text{ mos.}$$

Observed "t" = 1.74 and is less than  $t_{.05, 38 \text{ df}} = 2.025$ .

Therefore the duration of treatment of these two groups shows no significant difference at the 5 per cent level with 38 degrees of freedom, and the two groups may be compared.



TABLE 8  
EVALUATIONS OF ROOT LOSS BEFORE AND AFTER  
TREATMENT WITH BEGG TECHNIQUE

Case		Examiner			Score	Range	Increase	(Incr.) <sup>2</sup>	Type of Tooth Movement
		#1	#2	#3					
1	B	0	0	0	0				
	A	1	1	1	1	0 - 1	1	1	A - P.D.
2	B	1	0	1	1				
	A	2	2	2	2	1 - 2	1	1	A - P.D.
3	B	1	0	0	0				
	A	1	1	1	1	0 - 1	1	1	T.
4	B	1	0	1	1				
	A	2	2	2	2	1 - 2	1	1	L.B.
5	B	0	0	0	0				
	A	1	1	1	1	0 - 1	1	1	L.B.
6	B	0	0	1	0				
	A	2	2	2	2	0 - 2	2	4	L.B.
7	B	2	1	2	2				
	A	2	2	2	2	2 - 2	0	0	L.B.
8	B	0	0	1	0				
	A	2	2	2	2	0 - 2	2	4	T.
9	B	0	0	0	0				
	A	2	2	1	2	0 - 2	2	4	T.
10	B	0	0	0	0				
	A	2	1	1	1	0 - 1	1	1	A - P.D.
11	B	1	1	1	1				
	A	3	3	3	3	1 - 3	2	4	T.
12	B	1	1	0	1				
	A	1	0	1	1	1 - 1	0	0	A - P.D.
13	B	1	1	1	1				
	A	1	1	1	1	1 - 1	0	0	T.
14	B	1	0	1	1				
	A	2	2	2	2	1 - 2	1	1	L.B.
15	B	0	0	0	0				
	A	1	1	1	1	0 - 1	1	1	L.B.
16	B	1	1	1	1				
	A	1	2	1	1	1 - 1	0	0	A - P.D.
17	B	0	0	0	0				
	A	1	1	1	1	0 - 1	1	1	A - P.D.
18	B	0	0	0	0				
	A	1	1	0	1	0 - 1	1	1	A - P.D.
19	B	1	0	0	0				
	A	1	1	1	1	0 - 1	1	1	L.B.
20	B	2	0	0	0				
	A	1	1	1	1	0 - 1	1	1	A - P.D.

$$S = \frac{1}{20} \text{ S.S. } = \frac{1}{28}$$

B - Before treatment

A - After treatment

T - Apical tipping tooth movement

L.B. - Lingual bodily tooth movement

TABLE 9  
EVALUATIONS OF ROOT LOSS BEFORE AND AFTER TREATMENT  
WITH EDGEWISE TECHNIQUE

Case	Examiner			Score	Range	Increase	(Incr.) <sup>2</sup>	Type of Tooth Movement
	#1	#2	#3					
1 B	1	1	2	1				
A	2	2	2	2	1 - 2	1	1	L.B.
2 B	0	0	0	0				
A	1	1	0	1	0 - 1	1	1	T.
3 B	0	0	1	0				
A	2	2	2	2	0 - 2	2	4	A - P.D.
4 B	0	0	0	0				
A	1	1	1	1	0 - 1	1	1	T.
5 B	0	0	1	0				
A	1	1	1	1	0 - 1	1	1	T.
6 B	0	0	0	0				
A	0	0	1	0	0 - 0	0	0	L.B.
7 B	1	0	0	0				
A	2	2	2	2	0 - 2	2	4	A - P.D.
8 B	0	0	0	0				
A	2	2	2	2	0 - 2	2	4	A - P.D.
9 B	0	0	0	0				
A	2	1	1	1	0 - 1	1	1	L.B.
10 B	1	1	0	1				
A	1	1	1	1	1 - 1	0	0	L.B.
11 B	0	0	0	0				
A	2	2	2	2	0 - 2	2	4	L.B.
12 B	1	1	1	1				
A	1	1	1	1	1 - 1	0	0	L.B.
13 B	1	1	1	1				
A	2	2	2	2	1 - 2	1	1	T.
14 B	1	0	1	1				
A	1	1	1	1	1 - 1	0	0	L.B.
15 B	1	1	0	1				
A	2	1	1	1	1 - 1	0	0	L.B.
16 B	0	0	0	0				
A	1	0	0	0	0 - 0	0	0	L.B.
17 B	0	0	0	0				
A	2	2	2	2	0 - 2	2	4	T.
18 B	0	0	0	0				
A	1	0	1	1	0 - 1	1	1	T.
19 B	1	1	0	1				
A	2	2	2	2	1 - 2	1	1	A - P.D.
20 B	1	0	0	0				
A	2	2	2	2	0 - 2	2	4	A - P.D.

$$S = \frac{2}{20} \text{ S.S.} = \frac{4}{32}$$

## BIBLIOGRAPHY

1. Henry, J. L., and Weinmann, J. P.: The Pattern of Resorption and Repair of Human Cementum. *J.A.D.A.* 42: 270, 1951.
2. Massler, M., and Malone, A. J.: Root Resorption in Human Permanent Teeth. *Am. J. Orthodontics* 40: 619, 1954.
3. Hemley, S.: The Incidence of Root Resorption of Vital Permanent Teeth. *J. Dent. Research* 20: 133, 1941.
4. Phillips, J. R.: Apical Root Resorption Under Orthodontic Therapy. *Angle Orthodontist* 25: 1, 1955.
5. Begg, P. R.: Stone Age Man's Dentition, with Reference to Anatomically Correct Occlusion, The Etiology of Malocclusion, and a Technique for Its Treatment. *Am. J. Ortho.* 40: 298-312, 373-383, 462-475, 517-531, 1954.
6. Begg, P. R.: Differential Force in Orthodontic Treatment. *Am. J. Ortho.* 42: 481-510, 1956.
7. Begg, P. R.: Light Arch Wire Technique. *Am. J. Ortho.* 47: 30-48, 1961.
8. Storey, E., and Smith, R.: Force in Orthodontics and Its Relation to Tooth Movement. *Australia J. Dent.* 56: 11, 1952.  
Storey, E.: Factors Influencing the Design and Use of Removable Orthodontic Appliances. *Australia J. Dent.* 58: 230-236, 1954.
9. Jarabak, J. R.: Development of a Treatment Plan in Light of One's Concept of Treatment Objectives. *Am. J. Ortho.* 46: 481, 1960.
10. Jarabak, J. R., and Fizzell, J. A.: Technique and Treatment with the Light-wire Appliances, St. Louis, 1963, The C. V. Mosby Company.
11. Kronfeld, R.: The Resorption of the Roots of Deciduous Teeth, *Dental Cosmos* 74: 103, 1932.
12. Becks, H., and Cowden, R. C.: Root Resorptions and Their Relation to Pathologic Bone Formation. Part II. *Am. J. Ortho. and Oral Surg.* 28: 513, 1942.
13. Marshall, J. A.: The Classification, Etiology, Diagnosis, Prognosis and Treatment of Radicular Resorption of Teeth, *Int. J. Ortho.* 20: 731, 1934.



14. Ottolengui, R.: The Physiological and Pathological Resorption of Tooth Roots. *Dent. Items of Interest* 36: 332, 1914.
15. Ketcham, A. H.: A Preliminary Report of an Investigation of Apical Root Resorption of Permanent Teeth. *Internation J. Ortho., Oral Surg. and Radiog.* 13: 97, 1927.
16. Ketcham, A. H.: A Progress Report of an Investigation of Apical Root Resorption of Vital Permanent Teeth, *Int. J. Ortho.* 15: 310, 1929.
17. Marshall, J. A.: A Comparison of Resorption of Roots of Deciduous Teeth with the Absorption of the Permanent Teeth Occurring as a Result of Infection, *Int. J. Orthodontia* 15: 417, 1929.
18. Marshall, J. A.: Studies on Apical Absorption of Permanent Teeth. Part II. *International J. Ortho., Oral SURG., and Radiog.* 16: 1035, 1930.
19. Marshall, J. A.: The Relation of Malnutrition to Dental Pathology. *Internat. J. Ortho., Oral Surg. and Radiog.* 17: 527, 1931.
20. Rudolph, C. E.: A Comparative Study in Root Resorption in Permanent Teeth, *J.A.D.A.* 23: 822, 1936.
21. Rudolph, C. E.: An Evaluation of Root Resorption Occurring During Orthodontic Treatment, *J. D. Res.* 19: 367, 1940.
22. Fischer, B.: *Orthodontics.* W. B. Saunders Company, Philadelphia, 1952.
23. Johnson, A. L., Appleton, J. L., and Rittershofer, L. S.: Tissue Changes Involved in Tooth Movements. *Internat. J. Ortho., Oral Surg. and Radiog.* 12: 889, 1926.
24. Boyle, P. E.: *Kronfeld's Histopathology of the Teeth and Their Surrounding Structures.* Lea and Febiger, Philadelphia, 1949.
25. Oppenheim, A.: Human Tissue Response to Orthodontic Intervention of Short and Long Duration. *Am. J. Ortho. and Oral Surg.* 28:13, 1942.
26. Becks, H.: Root Resorptions and Their Relation to Pathological Bone Formation. *Internat. J. Ortho. and Oral Surg.*, 22: 445, 1936.
27. Becks, H.: Orthodontic Prognosis. *Am. J. Ortho., and Oral Surg.* 25: 610, 1939.
28. Schwarz, A. M.: Tissue Changes Incidental to Orthodontic Tooth Movement. *Internat. J. Ortho., Oral Surg. and Radiog.* 18: 331, 1932.

29. Orban, B.: Biologic Problems in Orthodontics. J.A.D.A. 23: 1849, 1936.
30. Oppenheim, A.: Biologic Orthodontic Therapy and Reality. Angle Orthodontist 6: 153, 1936.
31. Oppenheim, A.: A Possibility of Physical Orthodontic Movement. Am. J. Ortho. and Oral Surg. 30: 277, 1944.
32. Stuteville, O. H.: Injuries to the Teeth and Supporting Structures Caused by Various Orthodontic Appliances and Methods of Preventing These Injuries. J.A.D.A. 24: 1949, 1937.
33. Stuteville, O. H.: Injuries Caused by Orthodontic Forces and the Ultimate Results of These Injuries. Am. J. Ortho. and Oral Surg. 24: 103, 1938.
34. Salzman, J. A.: Orthodontics Practice and Technics. J. B. Lippincott Company, Philadelphia, 1957.
35. Salzman, J. A.: Roengenographic Cephalometrics. J. P. Lippincott Co., Philadelphia, 1961.
36. Jacobson, O.: Clinical Significance of Root Resorption. Am. J. Ortho. 38: 687, 1952.