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# A Survey of Treatment Characteristics in a University-based Graduate Orthodontic Program

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# A Survey of Treatment Characteristics in a University-based Graduate Orthodontic Program

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**A SURVEY OF TREATMENT CHARACTERISTICS IN A UNIVERSITY-  
BASED GRADUATE ORTHODONTIC PROGRAM**

A Thesis  
Presented for  
The Graduate Studies Council  
The University of Tennessee  
Health Science Center

In Partial Fulfillment  
Of the Requirements for the Degree  
Master of Dental Science  
From the University of Tennessee

By  
A. Brian Anderson  
May 2010

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## DEDICATION

I would like to dedicate this thesis to my parents, who have provided continued love and support throughout my life. They have taught me that with hard work and perseverance you can accomplish anything. Thank you, Mom and Dad, for everything.

## ACKNOWLEDGEMENTS

I would like to thank my thesis committee chairman, Dr. Edward F. Harris, for his help, support, and true patience with me in working on this project. Without his guidance this experience would not have been possible. I would also like to thank Dr. Richard A. Williams, and Dr. Jere L. Yates, the other committee members for their valuable input and guidance during this process.

## ABSTRACT

While there are a few national surveys on malocclusion in the U.S., few reports characterize actual orthodontic patients and their treatments. The purpose of this study was to describe the patients and their treatment at a university based orthodontic department, namely the University of Tennessee Health Science Center, Memphis. The goals of this study are: (1) to research patient demographics, dental and skeletal relationships and treatment variables; (2) to test for temporal trends in these patients and their treatment across a 26 year interval from 1980 to 2005; and (3) to assess the correlations among patient demographics, dental and skeletal relationships, and treatment variables. Data were collected from 1,500 patient records chosen at random from all cases. Girls represent 60% of the overall sample, a percentage that did not change over time. This preponderance of females is driven by greater perception of need, not more prevalent or more severe malocclusions. Non-White races have increased in the patient population, suggesting slow improvement of their chronic under-representation. Patients treated with orthognathic surgery account for 2% of overall cases, but this percentage decreased over the time interval. The mean starting age of child and adolescent patients was 13.4 years. Over time, the average patient age increased, reflecting more adult patients. Extraction cases of all types decreased over time from above 70% down to below 50% of cases. Over this same time, treatment duration has decreased, and more Angle Class I patients are being treated compared to Class II cases. Causes are multifactorial, but people with simpler malocclusions seeking treatment seem to be one factor. Non-extraction treatment was only found to be of shorter duration when compared to extraction of (4-4/4-4), (4-4/5-5), and (4-4/0-0); no other extraction pattern involving premolars was found to be of longer duration than non-extraction, and treatment duration difference between all extraction patterns were not significant. This survey provides a unique insight into the patient population and treatment and how these have changed over time and not only adds to the orthodontic literature, but serves a useful “audit” of treatment at The University of Tennessee Graduate Orthodontic Clinic.

## TABLE OF CONTENTS

<b>CHAPTER I: INTRODUCTION AND RATIONALE.....</b>	<b>1</b>
<b>CHAPTER II: REVIEW OF THE LITERATURE.....</b>	<b>3</b>
Reasons Patients Seek Orthodontic Treatment.....	3
Sex Differences and Malocclusion.....	4
Sex Differences and Orthodontic Treatment and Need.....	5
Racial Differences in Malocclusion and Treatment Need.....	8
Patient Age.....	9
Treatment Duration.....	10
Extractions in Orthodontic Treatment.....	11
Angle’s Molar Classification.....	13
<b>CHAPTER III: MATERIALS AND METHODS.....</b>	<b>15</b>
Data Collection.....	15
Case Distribution by Year.....	17
Statistical Analysis.....	17
<b>CHAPTER IV: RESULTS.....</b>	<b>20</b>
Ethnic Groups.....	20
Race and Sex Distribution.....	23
Race and Subsidized Treatment.....	23
Race and Orthognathic Surgery.....	23
Sex Distribution.....	24
Angle Classification.....	26
Angle Classification, Race, and Sex.....	30
Angle Classification and the FMA.....	30
Orthognathic Surgery.....	30
Age at Treatment.....	34
Treatment Mechanics.....	34
Extraction Frequency.....	38
TennCare Utilization.....	50
ANB Angle.....	50
Frankfort Mandibular Plane Angle.....	56
Duration of Treatment.....	56
Treatment Duration and TennCare.....	67
Treatment Duration, Angle Class and Extraction.....	67
Treatment Duration and the FMA and ANB Angle.....	69
Treatment Duration and Race.....	69



<b>CHAPTER V: DISCUSSION .....</b>	<b>73</b>
Ethnic Groups.....	73
Sex Distribution.....	74
Angle Classification.....	75
Orthognathic Surgery .....	77
Treatment Mechanics .....	77
Extraction Frequency.....	78
Treatment Duration.....	78
 <b>CHAPTER VI: SUMMARY AND CONCLUSIONS.....</b>	 <b>81</b>
 <b>LIST OF REFERENCES .....</b>	 <b>83</b>
 <b>VITA .....</b>	 <b>86</b>

## LIST OF TABLES

Table 1.	Proportions of the total sample by race or ethnic group (n = 1,612) .....	20
Table 2.	Results of logistic regression testing for a significant change in proportions of Blacks and Whites between 1980 and 2005.....	21
Table 3.	Results of logistic regression testing for a significant change in proportions of other patients and Whites between 1980 and 2005.....	22
Table 4.	Results of logistic regression testing for a significant change in proportions of boys and girls between 1980 and 2005 .....	25
Table 5.	Results of logistic regression testing for a significant change in proportions of Angle Class I and II patients between 1980 and 2005. ..	27
Table 6.	Results of logistic regression testing for a significant change in proportions of Angle Class I and III patients between 1980 and 2005.....	28
Table 7.	Results of logistic regression testing for a significant change in proportions of Angle Class II and III patients between 1980 and 2005.....	29
Table 8.	Results of logistic regression testing for a significant change in proportions of surgery and non-surgery patients between 1980 and 2005.....	33
Table 9.	Results of bivariate fit testing for a significant change in the start age over the quarter century surveyed.....	37
Table 10.	Results of logistic regression testing for a significant change in proportions of treatment mechanics for standard edgewise and straight-wire edgewise cases treated between 1980 and 2005.....	40
Table 11.	Results of logistic regression testing for a significant change in proportions of treatment mechanics for Begg and standard edgewise cases treated between 1980 and 2005.....	41
Table 12.	Results of logistic regression testing for a significant change in proportions of treatment mechanics for Begg and straight-wire edgewise cases treated between 1980 and 2005.....	42
Table 13.	Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for all cases treated between 1980 and 2005.....	43
Table 14.	Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for Begg cases treated between 1980 and 2005.....	44
Table 15.	Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for standard edgewise cases treated between 1980 and 2005. ....	45

Table 16. Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for straight-wire edgewise cases treated between 1980 and 2005.....	46
Table 17. Results of logistic regression testing for a significant change in proportions of four premolar extraction and non-extraction for all edgewise cases treated between 1980 and 2005.....	47
Table 18. Results of logistic regression testing for a significant change in proportions of two premolar extraction and non-extraction for all edgewise cases treated between 1980 and 2005.....	48
Table 19. Results of logistic regression testing for a significant change in proportions of four premolar extraction and two premolar extraction for all edgewise cases treated between 1980 and 2005.....	49
Table 20. Results of logistic regression testing for a significant change in proportions of TennCare cases and non-TennCare cases treated between 1980 and 2005.....	52
Table 21. Results of logistic regression testing for a significant change in proportions of TennCare cases and non-TennCare cases treated between 2000 and 2005.....	53
Table 22. Results of bivariate fit testing for a significant change in the ANB angle over the quarter century surveyed. ....	55
Table 23. Results of bivariate fit testing for a significant change in the FMA in all patients over the quarter century surveyed.....	58
Table 24. Results of bivariate fit testing for a significant change in the FMA in White patients over the quarter century surveyed. ....	59
Table 25. Results of bivariate fit testing for a significant change in the FMA in Black patients over the quarter century surveyed. ....	60
Table 26. Results of bivariate fit testing for a significant change in the FMA in “other” patients over the quarter century surveyed.....	61
Table 27. Results of bivariate fit testing for a significant change in time in treatment over the quarter century surveyed.....	63
Table 28. Results of bivariate fit testing for a significant change in time in treatment for Begg cases over the quarter century surveyed.....	64
Table 29. Results of bivariate fit testing for a significant change in time in treatment for standard edgewise cases over the quarter century surveyed. ....	65
Table 30. Results of bivariate fit testing for a significant change in time in treatment for straight-wire cases over the quarter century surveyed...	66
Table 31. Results of bivariate fit testing for a significant change in time in treatment by ANB angle .....	70
Table 32. Results of bivariate fit testing for a significant change in time in treatment by the FMA .....	71
Table 33. Proportions of the total sample by race compared with the respective proportions in the population of the city of Memphis. ....	73

Table 34. Proportions of Angle Class from various studies .....76

## LIST OF FIGURES

Figure 1.	Counts of cases studied distributed by the year the case was started .....	18
Figure 2.	Plot generated by a logistic fit of race (defined as Black or White) against the year the case was started .....	21
Figure 3.	Plot generated by a logistic fit of race (defined as White or other) against the year the case was started .....	22
Figure 4.	Frequency of boys compared to girls in all years, 1980 to 2005. ....	24
Figure 5.	Plot generated by a logistic fit of sex against the year the case was started .....	25
Figure 6.	Frequency of molar classification (Angle) in all patients (n = 5,255) .....	26
Figure 7.	Plot generated by a logistic fit of Angle Class I and II cases against the year the case was started .....	27
Figure 8.	Plot generated by a logistic fit of Angle Class I and III cases against the year the case was started .....	28
Figure 9.	Plot generated by a logistic fit of Angle Class II and III cases against the year the case was started .....	29
Figure 10.	Mosaic chart showing percentage of Angle Class by race (as defined as Black or White).....	31
Figure 11.	Frequency of molar classification (Angle) in Black patients.....	31
Figure 12.	Frequency of molar classification (Angle) in White patients .....	32
Figure 13.	Plot of the frequency of surgical cases as a function of start dates.....	33
Figure 14.	Plot of ages at the start of treatment (years) for all patients in the sample.....	35
Figure 15.	Plot of ages at the start of treatment (years) for patients age 6 to 17 (sexes and races pooled).....	35
Figure 16.	Plot of ages at the start of treatment (years) for patients age 18 and older (sexes and races pooled) .....	36
Figure 17.	Plot generated by bivariate fit between the year of case start against patient start age for all cases.....	37
Figure 18.	Histogram showing the number of cases treated with Begg, standard edgewise and straight-wire edgewise mechanics over the 26 years surveyed.. .....	39
Figure 19.	Histogram showing the number of cases treated with standard edgewise and straight-wire edgewise mechanics only (excluding Begg) over the 26 years surveyed. ....	39
Figure 20.	Plot generated by logistic analysis of treatment mechanics (standard edgewise, straight-wire) against the year the case was started .....	40

Figure 21. Plot generated by logistic analysis of treatment mechanics (Begg, standard edgewise) against the year the case was started.....	41
Figure 22. Plot generated by logistic analysis of treatment mechanics (Begg, straight-wire) against the year the case was started. ....	42
Figure 23. Plot generated by logistic analysis of extraction category against the year the case was started for all cases.....	43
Figure 24. Plot generated by logistic analysis of extraction category against the year the case was started for Begg mechanics only.....	44
Figure 25. Plot generated by logistic analysis of extraction category against the year the case was started for standard edgewise mechanics only.....	45
Figure 26. Plot generated by logistic analysis of extraction category against the year the case was started for straight-wire edgewise mechanics only. ....	46
Figure 27. Plot generated by logistic analysis of extraction category (Non-X, 4-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics. ....	47
Figure 28. Plot generated by logistic analysis of extraction category (Non-X, 2-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics. ....	48
Figure 29. Plot generated by logistic analysis of extraction category (4-Pre, 2-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics. ....	49
Figure 30. Mosaic plot showing frequency of extraction by Angle classification.....	51
Figure 31. Plot generated by logistic analysis of whether or not a patient had TennCare against the year the case was started for all years .....	52
Figure 32. Plot generated by logistic analysis of whether or not a patient had TennCare against the year the case was started for 2000 to 2005.....	53
Figure 33. Histogram showing the distribution of ANB angles in the quarter-century surveyed. ....	54
Figure 34. Plot generated by bivariate fit of ANB angle by start year for all cases.. ....	55
Figure 35. Histogram showing the distribution of the FMA in the quarter-century surveyed.....	57
Figure 36. Plot generated by bivariate fit of FMA by start year for all cases.....	58
Figure 37. Plot generated by bivariate fit of FMA by start year for White patients only.....	59
Figure 38. Plot generated by bivariate fit of FMA by start year for Black patients only.....	60
Figure 39. Plot generated by bivariate fit of FMA by start year for “other” patients only.....	61

Figure 40. Plot of time in treatment by mechanics .....	62
Figure 41. Plot generated by bivariate fit between the year of case start against time in treatment for all cases.....	63
Figure 42. Plot generated by bivariate fit of time in treatment by start year for Begg cases only.....	64
Figure 43. Plot generated by bivariate fit of time in treatment by start year for standard edgewise cases only.....	65
Figure 44. Plot generated by bivariate fit of time in treatment by start year for straight-wire cases only.....	66
Figure 45. Plot of time in treatment by whether or not the patient had TennCare .....	68
Figure 46. Mean treatment times for Begg, standard edgewise, and straight- wire edgewise mechanics by Angle class.....	68
Figure 47. Plot generated by bivariate fit of time in treatment by ANB angle.....	70
Figure 48. Plot generated by bivariate fit of time in treatment by the FMA.....	71
Figure 49. Plot of time in treatment by race.....	72

## CHAPTER I: INTRODUCTION AND RATIONALE

Malocclusion is common in the United States and other developed countries, with most children in the U.S. population warranting orthodontic treatment (Kelly and Harvey 1977; Brunelle *et al.* 1996). Misaligned teeth negatively impact an individual's quality of life in areas such as mastication, speech, and probably most importantly one's appearance along with other psychological and social ramifications (Birkeland *et al.* 1996; Zhang *et al.* 2006). Not all people who could benefit from orthodontic treatment actually seek treatment, but more than 30% of White, 11% of Hispanics, and 8% of Black young Americans have reported having had some form of orthodontic treatment (Proffit *et al.* 1998).

There are few reports in the literature characterizing orthodontic patient samples and their treatments. While there have been three national surveys of the U.S. population (most recently Brunelle *et al.* 1996), these do not address the nature of the subpopulation of people actually treated orthodontically. There are in fact, few data on (A) the sex ratio of patients, (B) the age distribution of patients, (C) the classification of patients (Angle), or what percentage of the patient pool is treated in the mixed dentition versus the early permanent dentition versus adulthood. Virtually all claims of patient composition and of patient trends over time (*e.g.*, an increase in adult patients) are anecdotal. *The Journal of Clinical Orthodontics* publishes surveys of Orthodontic practices (*e.g.*, Keim 2005), but these queries address issues of practice management (*e.g.*, income, brackets utilized, appliance type) rather than estimates of the patient composition.

As noted by Proffit (1994), a university-based orthodontic does not perfectly reflect treatment happening regionally or nationally. However, a large mix of faculty treating a large patient population roughly reflects patient populations and treatment techniques in private practice. Fundamental data are so sparse concerning who is receiving orthodontic treatment, that efforts in this direction are warranted.

The purpose of the present study is to describe the patient characteristics and their treatment at one university based graduate orthodontic teaching institution, namely The University of Tennessee Health Science Center, Memphis. Information from such a high volume "practice" with diagnosis and treatment from numerous faculty specialists provides a composite baseline that incorporates more treatment perspectives than seen in any given private practice. Of course, there are some inherent differences, such as an urban setting, lower fees (and longer appointment times), and selection for "good teaching cases" (*i.e.*,



more complex malocclusions), but these would seem to be offset by the opportunity to sample the large mix of specialists' treatment protocols.

The goals of this study were: (1) to research patient demographics, dental and skeletal relationships, and treatment variables; (2) to test for temporal trends in these patients and their treatment over a 26 year time period from 1980 to 2005; and (3) to determine if any correlations exist between patient demographics, dental or skeletal relationships, or treatment variables.

## CHAPTER II: REVIEW OF THE LITERATURE

### Reasons Patients Seek Orthodontic Treatment

Patients, and their parents, seek orthodontic treatment for a variety of reasons, and ultimately, a combination of factors determines whether treatment will be pursued. Dental health appears to be less of a priority to patients than esthetic concerns when deciding on orthodontic care, even if a significant disability exists (Jenny 1975). Patients seeking treatment do so for primarily esthetic reasons, with demand often based on psychological rather than functional factors (Prah-Andersen 1978; Albino 1984). Patients have rated improved appearance as the “number one” benefit of treatment with dental health rated as second, and they actually would rather have straight teeth than healthy teeth (Shaw 1991).

Socio-cultural norms of esthetics often determine whether an individual will seek care. Children and their parents want to be perceived as “normal” (Jenny 1975), and orthodontic treatment is seen as a way to enhance an individual’s social acceptance and self esteem (Shaw 1981). Peer relationships and first impressions are often based on one’s physical appearance (Albino 1984), and attractive children are rated as more nice and more intelligent than their non-attractive counterparts. Among college students, appearance was found to be the only other factor besides “short acquaintanceships” to be consistently related to popularity (Prah-Andersen 1978). Children who are taunted by others about their teeth reported higher dissatisfaction with their dental appearance and expressed a greater need for orthodontic treatment than those who did not report such harassment (Shaw 1981).

A higher percentage of girls receive orthodontic treatment than boys due to social and psychological differences between the sexes. In one report, girls had a higher dissatisfaction with their dental appearance than boys, with 68% of girls reporting dissatisfaction compared to 32% of boys (Shaw 1981). Also of interest, 75% of girls in a study by Cavior rated themselves as the least attractive in their class (Shaw 1981). In a British population of 11 to 14 year olds, girls had higher Child Perception Questionnaire scores than boys; they report a higher impact of malocclusion on emotional well being; and they expressed a greater desire for orthodontic treatment (O’Brien *et al.* 2006). Latvian girls answering a questionnaire reported that they had a need for orthodontics and were dissatisfied with their dental appearance more than Latvian boys did, even though the orthodontic need between the two groups was not different (Liepa *et al.* 2003). Shaw (1991) stated that the reason more girls than boys receive orthodontic care is due to sex role stereotyping, where society places a greater

importance on female physical attractiveness compared to that of males.

Prahl-Andersen (1978) noted that attractive females used in commercial advertising have contributed to the norms for beauty, and these models are the best sales promotions available to the orthodontist due to their promotion of beauty as the norm. An antiquated, but still possibly highly pervasive cultural thought, is that while an attractive man can seek out an attractive wife, an unattractive man can find an attractive wife given certain compensations such as money. An unattractive woman may not have such options when finding a husband (Prahl-Andersen 1978). Some parents may believe this to be true and be more inclined to provide orthodontic treatment for daughters rather than sons.

### Sex Differences and Malocclusion

Research on the occlusion of young people in the United States ages 12 to 17 from the National Health Examination Survey Cycle III (NHES III, 1966-1970) evaluated the incidence and severity of malocclusion using the Treatment Priority Index (Grainger 1967) and five specific components of malocclusion. Vertical overbite, overjet, posterior crossbite, tooth displacement and buccal segment relation were analyzed. The sample size of the study consisted of 7,500 youths who were selected to represent the youth of the continental United States as a whole. There was no statistical difference between males and females in any of the specific components of malocclusion. So too, there was no sex difference in the overall score of the malocclusion using the Treatment Priority Index (Kelly and Harvey 1977).

More recently, research on occlusion was conducted using the data from the Third National Health and Nutrition Examination Survey (NHANES III) collected in 1988 to 1991 on 7,000 people ages 8 to 50 years (Brunelle *et al.* 1996). This research did not look at an overall score of malocclusion (such had been done in the NHES III with the TPI) but, rather, at five individual components, namely incisor alignment, midline diastema, posterior crossbite, overjet, and overbite. The authors described these components as “disassociated” measures of malocclusion. Significant sex differences were not found in the categories of posterior crossbite, overjet, or overbite, but did exist in categories of anterior alignment and midline diastema, with males having a greater degree of malocclusion in these categories. Mean alignment scores show males having more crowding in the mandibular arch with males mean of 2.9 mm and females having a mean of 2.6 mm. The prevalence of a midline diastema  $\geq 2$  mm was present in 7.7% of males and in 5.3% of females (Brunelle *et al.* 1996). More females than males had received orthodontic treatment in this study, which would at least partly explain these small sex differences in the prevalence of

malocclusion because adolescents in treatment (or having completed treatment) were omitted from the analysis.

In a sample of 810 Italian school children (ages 11 to 14 years), the individual components of malocclusion of overjet, overbite, openbite, anterior and posterior crossbites, crowding, coincidence of the upper and lower midlines and diastema were measured (Ciufflo *et al.* 2005). Boys had an increased prevalence and increased mean value of overbite compared to girls, while the other measured components were the same between the sexes (Ciufflo *et al.* 2005).

Massler and Frankel (1951) looked at the occlusions of 2,758 U.S. high school students (ages 14 to 18 years) and measured variations of individual teeth from their ideal or normal relationships. Boys were affected slightly more often than girls by malocclusion at all age levels, with 4.4% more boys affected than girls. Boys also had a slightly higher number of maloccluded teeth than girls, with 10.96 per boy compared to 10.22 per girl. Of note, however, Sex differences in this study were not significant statistically (Massler and Frankel 1951).

Other studies on sex differences and malocclusion exist but almost none have samples as large as the ones just mentioned. Research has shown that, although males do have larger mesiodistal tooth sizes and arch dimensions than females, there is no sex difference in the risk or severity of malocclusion (Arya *et al.* 1974) because their arch and palate dimensions also are larger.

### Sex Differences and Orthodontic Treatment and Need

The NHES III data extrapolated to 2.4 million Americans ages 12 to 17 years show that significantly more females than males had received orthodontic treatment; 11.8% of girls and 9.6% of boys reported receiving orthodontic treatment of some kind. Parents of the surveyed adolescents who had not received orthodontic treatment were asked whether their child needed orthodontic treatment. Fewer parents of White male children reported that their sons needed treatment (9.6%) than the parents of daughters (13.3%). This sex difference also existed, in Blacks but to a lesser degree than in Whites.

The TPI scores of the children who were reported by their parents as having a need for orthodontics were different between boys and girls. The mean TPI score of Whites whose parents said they needed treatment was 7.6 for girls, but 8.9 for boys. Parents of untreated White girls who had been told by their dentist of their child's need for orthodontic treatment had an average TPI score of 7.8, while the boys who were told that they needed to see the orthodontist had

an average TPI score of 9.5. In contrast, there was no significant difference between the TPI scores of untreated Black boys and girls whose parents said that they needed orthodontic treatment or were told by a dentist that they needed treatment. Parents and dentists of White youths perceive a different level of malocclusion at which they see the need for treatment, with dentists having an even greater difference between the sexes than the parents. There was no sex difference in the self-perceived need for orthodontics in the children of NHES III. The percentage of children who said that they needed orthodontic treatment was 18%, with girls and boys responding about equally (Kelly and Harvey 1977).

In the data from NHANES III, a greater percentage of girls than boys had received orthodontic treatment: 20.5% of girls and 16.4% of boys had received treatment in the 8 to 17 age group and 22.7% of women and 14.2% of men in the 18 to 50 age interval. A lower percentage of males received orthodontic treatment compared to females in both age groups, but the difference may be declining. More boys and fewer girls in the younger age group are receiving treatment when compared to the older age group (Brunelle *et al.* 1996). This declining difference suggests changing attitudes in regards to sex differences in the perceived need for orthodontic treatment.

In a study of third and fourth grade school children in Florida (n = 3,696), 9.5% of the girls were receiving orthodontic treatment compared to 6.8% of the boys (Wheeler *et al.* 1994). Using the Index of Orthodontic Treatment and Need (IOTN), Wheeler and coworkers showed that more boys needed orthodontic treatment than girls, with boys having a 44.2% need and girls having a 41.8% need. With the definition of demand used in their study (*i.e.*, those currently in orthodontic treatment) this would make sense because more girls are currently in treatment and therefore would not be included in the “need” group.

Based on a review of 5,350 orthodontic cases treated in the Department of Orthodontics at The University of Tennessee Health Science Center, 40% of the patients are boys and 60% are girls, which, statistically, is a hugely biased sex ratio (Harris, unpublished data). In other words, girls are 1.5 times as likely as boys to be treated in this university setting. Of note, minor malocclusions are omitted from this graduate clinic population since prospective patients are screened for “good teaching cases” that would benefit from comprehensive rather than limited treatment. Other studies also found a 6 to 4 ratio of girls to boys. In a survey of 1,000 consecutively treated patients in Britain, and almost 1,500 patients in Belgium, this same ratio was reported (Rose 1974; Willems *et al.* 2001).

The United States is not alone in the disparity among males and females receiving orthodontic treatment. In a British study of 162 patients referred for

orthodontic treatment 54% were female and 46% were male (O'Brien *et al.* 1996). Of those patients referred to an orthodontist by a general dentist or other health care professional, 54% were accepted for treatment. Acceptance criteria were based on whether the orthodontist felt that there was sufficient treatment need. Of the patients who were accepted for treatment, 62% were female and 38% were male. Using the IOTN to compare malocclusions of all of the children, the study showed that, when a need for orthodontic treatment was present, a girl was three times more likely to be accepted for orthodontic treatment than a boy. Furthermore, the child's sex was predictive of patient acceptance of treatment: boys were less likely than girls to undergo treatment once accepted for free treatment in the British healthcare system. O'Brien and coworkers (1996) attributed these differences to sex role stereotyping, explaining that society considers the physical appearance of girls to be more important than that of boys.

A study of 920 randomly selected orthodontic patients from the Netherlands revealed that 400 were males and that 520 were females (Al Yami *et al.* 1998). The IOTN was performed on the pretreatment casts and the results showed that 83% of the patients fell into the definite-need category of the combined dental health component (DHC) and aesthetic component (AC) of the IOTN. Males and females did show small but significant differences both on the DHC and the AC. Males had a greater need for treatment than females in the aesthetic component, with scores of 8.0 and 7.8, respectively. Males also showed a greater need in the dental health component with scores of 4.1 compared to 3.9. Al Yami and coworkers claimed that these differences are small and not clinically significant, but significance occurs in the fact that, although males have only a slightly greater treatment need, they are outnumbered in the orthodontic sample by a 5.2 to 4.0 ratio of females to males.

In a study group of 359 eleven-year-old Norwegian school children scored with the IOTN, 53.2% of children had a moderate to very great need of treatment using the DHC while 29.4% had the same need according to the AC. No significant difference was found between girls and boys for need of orthodontic treatment using either of the two parts of the IOTN (Birkeland *et al.* 1996).

In a French study of 531 orthodontically untreated school children ages 9 to 12 years, there was no significant difference in orthodontic treatment need between girls and boys using either the DHC or the AC components of the IOTN. About 21% of the children warranted orthodontic treatment using the IOTN grades of need (Souames *et al.* 2006).

In a sample of 223 randomly selected first-year university students in Hong Kong, males and females had no significant difference in orthodontic

treatment need using two different indices, namely the IOTN and the Occlusal Index (Tang and So 1994).

Latvian school children (n = 504) were assessed using the Index of Complexity, Outcome, and Need (ICON), and no difference of treatment need was found between the sexes (Liepa *et al.* 2003). About 35% of the children in the study were found to have a need for orthodontic treatment (Liepa *et al.* 2003).

### Racial Differences in Malocclusion and Treatment Need

Data from the NHES III reveal that consistent differences in the average TPI scores of youths ages 12 to 17 are not associated with race; that is to say that there is not an overall greater need for treatment in any one racial group (Kelly and Harvey 1977). In this sample (n = 7,500), significantly more Blacks (8.2%) than Whites (5.0%) have TPI scores  $\geq 10$  indicating a severe need for orthodontic treatment, but significantly more Blacks (14.7%) than Whites (10.5%) also have a TPI score of zero, indicating no need for treatment (Kelly and Harvey 1977). However, Whites who had been or were being treated were not included in the counts, so any race difference is minor. In terms of certain individual components of malocclusion racial differences were noted. Blacks are more likely than Whites to have a Class I (62% compared to 52%) or a Class III (19% compared to 13%) molar relationship, while Whites are more likely to be Class II molar (34% compared to 18%). White children are more likely to have a deep bite, while Black children are more likely to have an open bite. Whites were also more likely to have higher tooth displacement scores indicating more crowding (Kelly and Harvey 1977). Even though these racial differences do exist, overall there is no difference between Blacks and Whites in treatment need. Data from the NHANES III also looked at Mexican-American children. Mexican-Americans were nearly twice as likely as Blacks or Whites to have extreme crowding in the anterior segment and tended to have more extreme Class II malocclusions than Whites and more extreme Class III malocclusions than Blacks. However, they were much less likely than either Whites or Blacks to have vertical deviations from the ideal (Proffit *et al.* 1998). As assessed by the Index of Orthodontic Treatment and Need (IOTN), Blacks, Mexican-Americans, and Whites were found to have very similar total treatment need with about 55% of the sample having some degree of treatment need. However, Blacks were found to have a significantly higher severe need than Mexican-Americans and Whites. This is attributed to the fact that this is a mixed sample of treated and untreated subjects and that fewer Blacks who had a severe need of treatment actually received that treatment (Proffit *et al.* 1998).

While different racial groups have the same overall need for orthodontic treatment, there are substantial racial disparities in the number of orthodontic visits reported by Black and Hispanic children (Okunseri *et al.* 2007). Data from 1996 to 2004 indicate that of respondents age 9 to 18 with at least one orthodontic office visit in the previous year, 85% were White, 4.5% were Black, 6.7% were Hispanic, 2.5% were Asian, and the rest were “other” (Okunseri *et al.* 2007). When covariates such as income and health insurance were removed these disparities still existed in all years for Black children compared to White children, and in three of the nine years for Hispanic children compared to White children. Okunseri *et al.*, conclude that these differences in orthodontic office visits are not only socioeconomic, but also cultural (2007).

Data from the NHANES III reveal that Whites were significantly more likely than non-Hispanic Blacks and Mexican-Americans to have had orthodontic treatment. In the 8 to 17 age range 22.9% of Whites, 6.1% of Blacks and 8.3% of Mexican-Americans had received orthodontic treatment. In the 18 to 50 age range, 22.2% of Whites, 5.0% of Blacks, and 6.1% of Mexican-Americans had received treatment.

Manski *et al.* found that, overall, non-Whites were less likely to visit an orthodontist, but that from 1987 to 1996 the percentage of non-Whites visiting an orthodontist significantly increased from 1.5% to 2.1%. During this time the percentage of Whites visiting an orthodontist increased slightly, but not significantly, from 3.5% to 3.6% (Manski *et al.* 2000).

In a sample of third and fourth grade children (n = 3,696), demand was found to be higher in White children than in Black children with 11.8% of White children’s parents wanting treatment compared to 1.2% of Black children’s parents. In this sample, however, White children had a greater need for treatment (47.2%) than Black children (35.3%) (Wheeler *et al.* 1994).

### Patient Age

As recently as the late 1960s to the early 1970s, around 95% of all orthodontic patients were children or adolescents. By 1990, the percentage of adult patients had increased five-fold, to 25%, but has since declined to around 15-20% in the late 1990s (Buttke and Proffit 1999; Proffit 2007). This drop seen in adult patients was only a drop in percentage, as the absolute number of adults in treatment had not appreciably changed while the number of adolescents and seeking treatment has increased (Proffit 2007). Data from 1996 indicate that of all orthodontic patients, children under 12 represent 20.3% of the total, children 12 to 18 represent 54.4%, and adults 19 years and older compromised 25.3% (Guay



*et al.* 2008). It is clear that the composition of patients treated for orthodontics is changes across time, although not as drastically now as it once did.

In a sample of 65,000 U.S. adults, 1% has had an orthodontic office visit in the past year, with 65% of these patients being women and 35% being men (Whitesides *et al.* 2008). Whites, Blacks, and Hispanics in this adult sample were proportionally represented in comparison to the national population (Whitesides *et al.* 2008).

In reviewing orthodontic insurance claims in the state of Washington, Huang *et al.*, found a patient age range of two to eighty-nine years old and found that 86% of the patients were less than twenty years of age (Huang *et al.* 2004). In a study of 1,000 consecutively treated British patients, the mean age of the first orthodontic consult was 10.7 years, while the mean age of start is 11.6 years. Two-thirds (69%) of the cases treated began between the ages of 10 and 13 (Rose 1974).

### Treatment Duration

Orthodontic treatment duration is highly variable and depends on many factors of treatment need, treatment modality, and patient cooperation. Depending on the research cited, average reported treatment can range from 22 to 31 months (Vig *et al.* 1990; Fink and Smith 1992; Alger 1998). Factors that may affect treatment duration include case difficulty, number of phases of treatment, number of broken appointments, broken appliances, poor oral hygiene, poor headgear wear, poor elastic wear, ANB angle, and mandibular plane angle (Vig *et al.* 1990; Fink and Smith 1992; Beckwith *et al.* 1999)

Interestingly, the literature does not agree on whether extractions as part of treatment affect treatment duration. Beckwith *et al.* found that extraction cases took 1.4 months longer to treat than non-extraction cases, but this difference was not significant (1999). Fink and Smith (1992) report that premolar extraction is the most important variable explaining differences in duration of treatment. They found that each extracted premolar increases treatment time by 0.9 months and that four premolar extraction increases treatment time by 3.6 months, a significant difference. Alger reported that extraction cases average 4.6 months longer than non-extraction cases (1998). Vig *et al.* (1990) found that when the patients of multiple practices were pooled, that there was no difference in treatment time for extraction and non-extraction patients. However, when each of the five private practices from which they gathered their cases were considered individually, each of the five had a significant difference between the treatment times of extraction and non-extraction cases.

Patient characteristics reported to affect treatment time are Salzmann score, ANB angle, and the mandibular plane angle. Fink and Smith (1992) found that treatment time increases as the ANB angle and Salzmann score increase, but, to their surprise, they also found that treatment time decreases 0.3 months per degree increase of the mandibular plane angle.

### Extractions in Orthodontic Treatment

The great premolar extraction debate has been going on throughout the history of orthodontics with strong emotion and enthusiasm. In the early twentieth century, Edward H. Angle and his followers were strict non-extractionists, but by the 1950s extraction in orthodontics became more common with the introduction of Charles H. Tweed's modifications of Angle's edgewise appliance and P. Raymond Begg's introduction of his light-wire appliance. Tweed championed extractions in order to upright mandibular incisors over basal bone in hopes of maximizing the stability of the post-orthodontic dentition and to enhance facial esthetics. Tweed estimated that four-premolar-extraction was necessary in approximately 50% of all cases (Tweed 1945). Begg favored premolar extraction based on the fact that the soft diet of modern man did not allow for the considerable interproximal attrition observed in the stone-age man and that four premolar extraction could simulate this attrition and alleviate malocclusion (Begg 1954). As Tweed and Begg's perspectives and appliances became popular, extraction treatment became very common in the U.S. (Proffit 1994).

The frequencies of extractions are perceived to have varied appreciably over time and with regard to individual practitioners. However, there are relatively few reports in the literature on actual extraction frequencies and extraction patterns.

Peck and Peck (1979) examined the records of 537 of their own patients and documented an overall extraction rate of 42.1%. A third (36%) of their patients received extractions in both arches, while 5% had extractions in the maxillary arch alone, and 1% had extractions in the mandibular arch alone. Interestingly, they also found that females were more likely to have extractions, with 44.3% of females receiving extraction compared to 39.0% of males; it is not reported whether or not this difference is significant (Peck and Peck 1979). Peck and Peck also compared their extraction rates with other reports, and they gave a range of extraction frequency reported in the literature from 6.5% (Case in 1913) to 83.5% (Hooper in England in 1967). Other reported extraction percentages in

the United States were 80% reported by Tweed in 1966 and 33% reported by Ricketts in 1976 (Peck and Peck 1979).

In a telephone survey of Michigan orthodontists (n = 264) conducted from 1986 to 1987, the average extraction frequency was determined to be 39% of patients with reported ranges from 5% to 85% (Weintraub 1989). The most frequent extraction percentages reported were 25% and 50%, with 34% of participants each reporting these percentages. Orthodontist's self-estimations of extraction percentages were determined to be inaccurate when the researchers looked at the practices of those orthodontists in the extreme ranges of extraction frequency. Actual extraction rates ranged from a 20% overestimate of extractions to a 15% underestimate. In one practice, only 6.5% of patients were treated non-extraction, while in others, only 5.2% and 11.5% were treated with premolar extractions (Weintraub 1989). Most (70%) of the extraction cases studied had four premolars extracted, and the average extraction rate per patient was found to be 3.5 teeth (Weintraub 1989).

Results from a questionnaire mailed to orthodontists in the United States showed that extraction rates declined 22% between 1984 and 1989, from a frequency of 38% in 1984 to 29% in 1989. Over 50% of the responding orthodontists reported a decrease in extraction frequency, while 3% reported an increase in extraction frequency (Brian and O'Connor 1993). Reported reasons for the decrease in extraction rates were a desire for improved facial esthetics, TMJ concerns, and medicolegal concerns (Brian and O'Connor 1993).

Proffit (1994) reviewed 400 orthodontic cases treated over a 40 year period from 1953 to 1993 at The University of North Carolina. In 1953, extractions were part of treatment in 30% of the patients, but, by 1963, the extraction frequency had more than doubled to 73%, and it eventually rose to its peak of 76% in 1968. Since 1968, however, the extraction frequency slowly and steadily declined to 28% in 1993, only slightly below its 1953 level (Proffit 1994). Four first-premolars were extracted in 10% of the reviewed cases in 1953. This percentage jumped to 50% in just ten years and, by 1993, it had fallen to just below 1953 levels. Class II camouflage treatment (extraction of upper first premolars or upper first premolars and lower second premolars) did not show a statistically significant change over time. The prevalence of camouflage treatment peaked in 1968 and 1973 at 16% of cases and fell to 8% in 1993, which was the same frequency as four first-premolar extractions. One of every six extraction patients had an extraction category of "other" which included uneven premolar extractions, mandibular incisor extractions, and extractions of impacted teeth (Proffit 1994).

Factors affecting the decision of whether to extract teeth are variable and have changed over time. Personal preferences of the orthodontist, features of the

malocclusion, treatment objectives, and treatment techniques are some major factors in the extraction decision (Weintraub 1989). Weintraub found no association between either the orthodontic program attended or year of graduation and the frequency of extraction (1989). Brian and O'Connor (1993) found that orthodontists who had been in practice fewer than 5 years reported an extraction rate of 26% compared to an extraction rate of 31% of those who had been practicing more than 20 years. These data suggest that more recent graduates are more likely to treat cases non-extraction. Proffit noted that at the University of North Carolina there were very few changes in faculty during any given time period in which large changes in extraction patterns occurred (1994). This suggests that personal attitudes regarding extraction, and not changes in the faculty *per se* were the cause for changes in extraction frequencies.

Reasons for the decline in extraction as part of treatment are numerous. Normal ideals for facial esthetics have changed, and the literature reveals that long-term stability is not improved by extraction (Proffit 1994). Increased utilization of functional appliances and of palatal expansion has decreased the need to extract teeth in some cases involving molar correction and crowding (Weintraub 1989). In the 1980s many orthodontists began bonding brackets rather than using fully-banded fixed appliances. This allowed for more space for the teeth and thus less need for extraction in borderline cases (Proffit 1994). Concerns over premolar extraction and the development of temporomandibular disorder, although unwarranted, also caused orthodontists to be less likely to extract teeth (Proffit 1994).

### Angle's Molar Classification

Edward H. Angle gathered data on "thousands of patients" with malocclusions and reported his findings in his famous *Malocclusion of the Teeth* (7<sup>th</sup> edition) published in 1907. Angle found that 69.2% of his patients were Class I molar, 21.6% were some form of Class II molar, and 4.2% were Class III molar.

Data from the Evanston Dental Caries Study reveal Angle's Molar classification on over 25,000 untreated children. Two-thirds (69%) of children in the 6 to 8 year old range were reported to be "normal," which is undefined, but presumably a Class I molar relationship with little or no other variables of malocclusion present. For children in the 12 to 14 year old age group, only 54% were classified as "normal." Of the younger group, 19% were considered to have a Class I malocclusion, 11% to have a Class II malocclusion, and 1% to have a Class III malocclusion. Of the older group, 30% were considered to have a Class I malocclusion, 14% to have a Class II malocclusion, and 1% to have a Class III

malocclusion. Therefore, Class I malocclusion increased 11%, Class II, 3%, and Class III, did not increase at all from the younger group to the older group. Overall, the total was found to be a 14% increase in the prevalence of malocclusion (Emrich *et al.* 1965). Like previously mentioned studies, Blacks were found to be more likely to have a Class III molar relationship, and Whites to have a Class II relationship, although statistics were not performed to reveal these differences as significant (Emrich *et al.* 1965).

Data from the NHES III, collected on a mixed sample of treated and untreated children, reveal that 53% of children are Angle Class I molar, 32% are Class II, and 14% are Class III (Kelly and Harvey 1977). Racial differences in Angle's classification found in the NHES III were mentioned in the previous section.

Data collected on almost 1,500 Belgian patients presenting for treatment between 1983 and 1997 showed that 31% of the sample had a Class I molar, 62% had a Class II molar and 6% had a Class III molar (Willems 2001). It is importance to realize that although not all in this sample were treated, all patients did appear at university based orthodontic clinic and probably had more than mild malocclusions.

Massler and Frankel (1951) found that in a sample of Caucasian schoolchildren (n = 2758), 3% had an ideal occlusion, 18% had a "normal" occlusion, 50% had a Class I malocclusion, 19.4% had a Class II malocclusion, and 9% had a Class III malocclusion. Using the same techniques as Massler and Frankel, Altemus studied Black children (n = 3,289). He found that 4% had an ideal occlusion, 13% had a "normal" occlusion, 66.4% had a Class I malocclusion, 12% had a Class II malocclusion, and 5% had a Class III malocclusion (1957). Data from these two studies are inconsistent with other studies that show Blacks have a greater incidence of Class III malocclusions than Whites.

## CHAPTER III: MATERIALS AND METHODS

### Data Collection

Data were collected on 1,500 orthodontic patients treated at the graduate clinic of the Department of Orthodontics at the University of Tennessee, Memphis, representing approximately one-fourth of the patients treated at this clinic since 1980. The choice of starting at 1980 is due to an historical practicality. While the graduate orthodontic program has existed since 1942, archived patient records were disposed of (for lack of storage space) when the Department moved to its present location in the Dunn Dental Building in 1980. In that pre-computer era, disposal of the physical records removed all traces of the patients' files.

For the present study, Patient charts (consisting of progress notes, photographs, radiographs, and other documents) were examined from the University of Tennessee archives in alphabetical order with the intent of eliminating any selection bias. The only inclusion criteria were that a patient must have started orthodontic treatment after January 1, 1980, and finished before December 31, 2005. Patient charts were examined page by page. All documents in the chart were reviewed for relevant information. Data were collected on the following points.

- A. Patient ID Number: Patient ID number was collected for identification and organization purposes only. No identifying information was collected.
- B. Sex: Patient sex was determined primarily by visual identification from photographs and the Christian name. Otherwise, it was gathered from the health history or other paperwork in the chart.
- C. Race: Racial category was determined by photographic identification, based primarily on skin color, nose, and hair form. We recognized seven categories of "race": Asian, Black, Hispanic, Indian, Islander, middle-eastern and White. The intent here merely was to document the commonly perceived increase in non-Caucasian patients and their distribution over time. We fully appreciate that "race" is a nebulous, complex issue (Montagu 1964; Edgar 2009).
- D. Instructor: Instructor data were recorded by name of the attending faculty member. Using instructor data provided the type of fixed orthodontic appliance used in patient treatment of the cases. If name of the instructor was unavailable, appliance type was determined by photographs or treatment mechanic descriptions when available and was recorded as Tweed, Begg, Straight-wire, or "other."
- E. TennCare: TennCare is Tennessee's Medicaid managed care program that provides services for low income children and adolescents. If it was indicated in the patient chart either in the initial progress notes or in other

documentation, the patient was recorded as a TennCare (or other subsidized treatment) patient. If no documentation was found indicating that a patient has been subsidized by any social program it was assumed that the patient was not a TennCare patient.

- F. Birth Date: Patient's birth date was recorded in order to determine patient age at the start and end of treatment as well as the duration of treatment. If the date of birth was unavailable, but a patient age is found in the record, a birth date of January 1, for the relevant year was recorded so that a close estimate of the patient age could be made.
- G. Start Date: Patient start date was recorded to determine patient age at the start of treatment. Start date was determined by review of the progress notes and was defined by date of first cementation of orthodontic brackets, bands, or appliances used in any capacity other than space maintenance (*i.e.* a lower lingual arch or Nance appliance) or delivery of a removable functional appliance (*i.e.*, a Bionator or a Fränkel appliance) or an active retainer. Start date was not based on the date of initial records.
- H. Deband Date: Patient deband date was recorded to determine patient age at the end of treatment and treatment time duration.
- I. Angle's Classification: Patient Angle's classification was obtained from information in the patient's chart.
- J. FMA: Patient pretreatment Frankfort-mandibular-plane angles (Tweed 1946) was recorded from chart documentation. When this information was unavailable in the chart, FMA was measured directly from the pretreatment lateral cephalogram.
- K. ANB: The ANB angle (Riedel 1952; Steiner 1953) was recorded from chart documentation. When this information was unavailable, the ANB angle was measured directly from a pretreatment lateral cephalogram.
- L. Extraction Pattern: Extraction patterns were recorded using a numerical code as follows:
  - 1. Non-extraction
  - 2. Four first premolars (4-4/4-4)
  - 3. Four second premolars (5-5/5-5)
  - 4. Maxillary first premolars and mandibular second premolars (4-4/5-5)
  - 5. Maxillary second premolars and mandibular first premolars (5-5/4-4)
  - 6. First molars (6-6)
  - 7. Second molars (7-7)
  - 8. Maxillary first premolars only (4-4/0-0)
  - 9. Mandibular first premolars only (0-0/4-4)
  - 10. Maxillary second premolars only (5-5/0-0)
  - 11. Mandibular second premolars only (0-0/5-5)
  - 12. Other extraction patterns
  - 13. Incisor extractions

- M. Orthognathic surgery: If the progress notes or other documentation indicated that a patient had completed orthognathic surgery, this category was recorded as “yes.” Patients who were treatment planned for orthognathic surgery, but who did not follow through with this treatment were recorded as a “no.”
- N. Untreated: Patients who had records taken but who did not begin treatment were recorded as “no,” so the number of cases on whom initial records were taken but treatment was not performed could be analyzed. These patients either were not approved by TennCare, or declined treatment after presentation of the treatment plan.
- O. Incomplete Treatment: Patients who started treatment, but whose appliances were removed early for non-compliance or patients who moved away during active treatment were recorded as “yes.”
- P. Miscellaneous: Any extra information deemed interesting was recorded here. For example, if a patient had a cleft lip and palate, any syndrome, or special medical condition, it was noted here.

### Case Distribution by Year

Cases were selected at random (based on patient code), and it was left to chance whether the sample distribution was uniform across the time interval of 1980 through 2005. In fact (**Figure 1**), the distribution is fairly proportional across the 26 years. Most counts were between 40 and 60 per year, with a minimum of 31 for 1989 and cases in excess of 80 for the three years 2002 to 2004.

### Statistical Analysis

The data collected are several sorts: nominal, ordinal, interval, and ratio. Broadly, chi-square analysis (contingency tables) was used for nominal and ordinal data, with the data presented as proportions and/or percentages. The higher level data were described with standard descriptive statistics (Sokal and Rohlf 1995), followed by inferential text, as appropriate.

One prime theme here is to test for temporal differences: whether demographic conditions in the patient pool and/or treatment characteristics have changed over the quarter-century of patient records sampled. The individual tests are described in the text, but the general plan was to use the year of the starting records as the independent variable and the patient’s status (*e.g.*, age, FMA) or a feature of treatment, such as extractions or orthognathic surgery, as the outcome. When the dependant variable is interval or ratio scale,



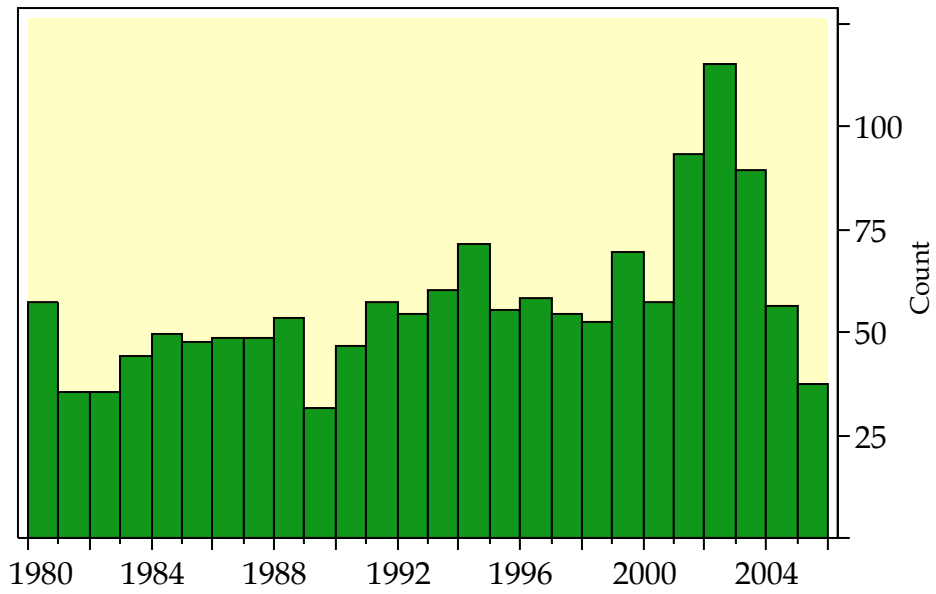


Figure 1. Counts of cases studied distributed by the year the case was started. Total sample is 1,470.

conventional regression models are suitable (*e.g.*, Freund and Littell 1991). When the variable is nominal or ordinal, a nominal logistic model was used.

Unless noted, tests were evaluated as two-tail, and the conventional level of  $\alpha = 0.05$  was used throughout, without any allowance for multiple comparisons.

## CHAPTER IV: RESULTS

### Ethnic Groups

“Race” is a very nebulous term (Montagu 1964; Edgar and Hunley 2009). The purpose here is simply to test the perception that non-Caucasian cases have achieved greater access to orthodontic care as time has advanced. Several studies show that non-Caucasians are underserved in health-care contexts. Race designation was available for a total of 1,612 individuals (**Table 1**). It is evident from this table that most of the patients are Whites (75%), most of the others are Blacks (21%), and other groups only compose 4% of the cases overall.

Our perception is that non-White races as orthodontic patients have become more common with time, both as racial proscriptions have diminished in the community and (concomitantly) more ethnic groups have moved into the greater Memphis community. Logistic regression was used to test for a trend comparing White and Black patients and White and other patients over the studied time interval. The frequencies of Black patients and of “other” patients have increased significantly with time when compared to White patients ( $P = 0.0005$ : **Figure 2, Table 2**;  $P = 0.005$ : **Figure 3, Table 3**, respectively).

In the range of years studied, the proportions of Blacks and of other non-Caucasian ethnic groups have increased significantly. However, the census of the City of Memphis proper is 61% Black, and the under-representation of Blacks among those attending this orthodontic clinic mirrors that seen nationally (*e.g.*, Proffit 1998), where non-White groups in general, but American Blacks in particular are under-represented. There almost certainly are multiple causes for the under-representation, but differences in disposable income commonly are cited.

Table 1. Proportions of the total sample by race or ethnic group (n = 1,612).

Race	Count	Percent
Asian	29	1.799
Black	342	21.216
Hispanic	7	0.434
Indian	11	0.682
Islander	1	0.062
Mideast	5	0.310
White	1217	75.496

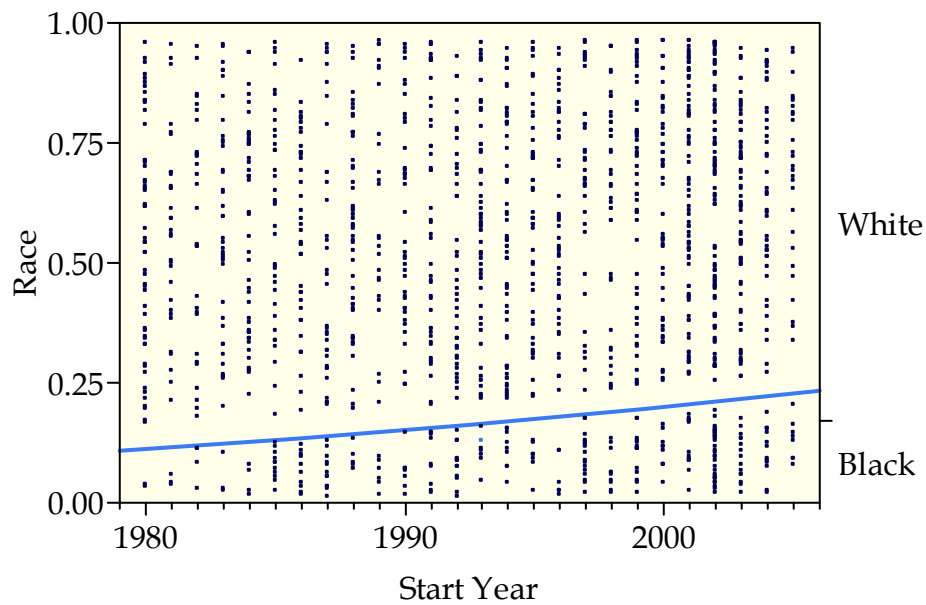


Figure 2. Plot generated by a logistic fit of race (defined as Black or White) against the year the case was started.

The frequency of Black patients as compared to White patients increased significantly through time in the quarter-century interval.

Table 2. Results of logistic regression testing for a significant change in proportions of Blacks and Whites between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	-68.799773	19.741288	12.15	0.0005
Start Year	0.03370783	0.0098956	11.60	0.0007

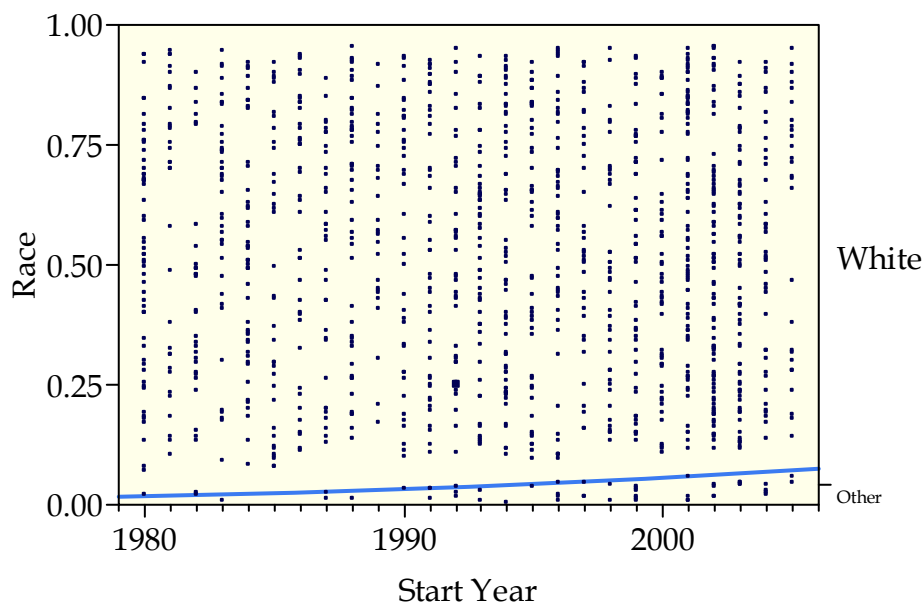


Figure 3. Plot generated by a logistic fit of race (defined as White or other) against the year the case was started.

The frequency of other patients as compared to White patients increased significantly through time in the quarter-century interval.

Table 3. Results of logistic regression testing for a significant change in proportions of other patients and Whites between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	-119.60276	42.473344	7.93	0.0049
Start Year	0.05837976	0.0212757	7.53	0.0061

## Race and Sex Distribution

Glassell and Harris (2007) reported that the characteristic preponderance of girls seen in the White orthodontic patient population is not present in the Black patient population, where the two sexes are represented about equally. They found that the proportion of girls with lower treatment-needs who inflated the percentage of White female patients was absent in the Blacks. We are unaware of any study that has tested for Black-White differences in self-perceptions of malocclusion – which also may influence seeking treatment.

In this particular sample, the percentage of girls in the Black sample (61%; 208/342) is not significantly different than in the White sample (58%; 711/1,217) as tested by chi-square analysis ( $X^2 = 0.6$ ;  $P = 0.42$ ). That is, there is an equivalent preponderance of girls compared to boys in both races.

## Race and Subsidized Treatment

One measure of financial influences on utilization is whether the groups had different uptake of government subsidized treatment, notably TennCare. Overall, almost 5% of the cases in this study were financially supported by TennCare (5%; 72/1,496). However, the percentage of Blacks (17%) is significantly higher than of Whites (2%), with a chi-square of 97.9 ( $df = 1$ ;  $P < 0.0001$ ).

It was tested whether those Blacks whose treatment was financed by TennCare exhibited more-deviant malocclusions. Two skeletal measures were tested (FMA, ANB), but neither of these angles differed in the TennCare compared to the self-paid sample of Blacks. This suggests that the differences depend more on the extent of the tooth-based malocclusions than on differences in the supporting bony relationships.

## Race and Orthognathic Surgery

We also tested whether orthognathic treatment differed by race. Blacks in our sample had a somewhat higher frequency of orthodontic-surgery treatments (2.3%; 6/257) compared to Whites (1.8%; 21/1,187), but the difference is not significant statistically ( $X^2 = 0.3$ ;  $P = 0.55$ ), primarily because the sample sizes are small.

## Sex Distribution

There is a clear preponderance of girls over boys in the treated sample. The patient's sex was known for a total of 6,927 cases, and 59% were female. By chi-square this deviates significantly from an expected split of 50:50 ( $X^2 = 231.6$ ; 1 df;  $P < 0.0001$ ). In other words about 1.5 girls were treated for every boy. As discussed later, this predominance of girls probably stems from their greater (and their parents') greater esthetic concern compared to boys. This greater esthetic concern – and concern about lesser esthetic problems – is well-documented in the dental literature (*e.g.*, Shaw 1991). The sex ratio of patients, at about 60:40 (**Figure 4**), has been very stable throughout the quarter century of records reviewed here. By logistic regression (sex on year; **Figure 5, Table 4**) the preponderance of girls in the patient pool has been quite consistent throughout the surveyed time ( $X^2 = 0.12$ ;  $P = 0.73$ ).

The excess of girls – compared to boys – is the same in Blacks and Whites (other races are too uncommon for analysis). In Whites, 58% are girls and 42% are boys (total  $n = 1,217$ ). By chi-square analysis, this ratio is the same as Blacks, where 61% are girls and 39% are boys (total  $n = 342$ ). The chi-square test (1 df) is 0.6 ( $P = 0.04261$ ).

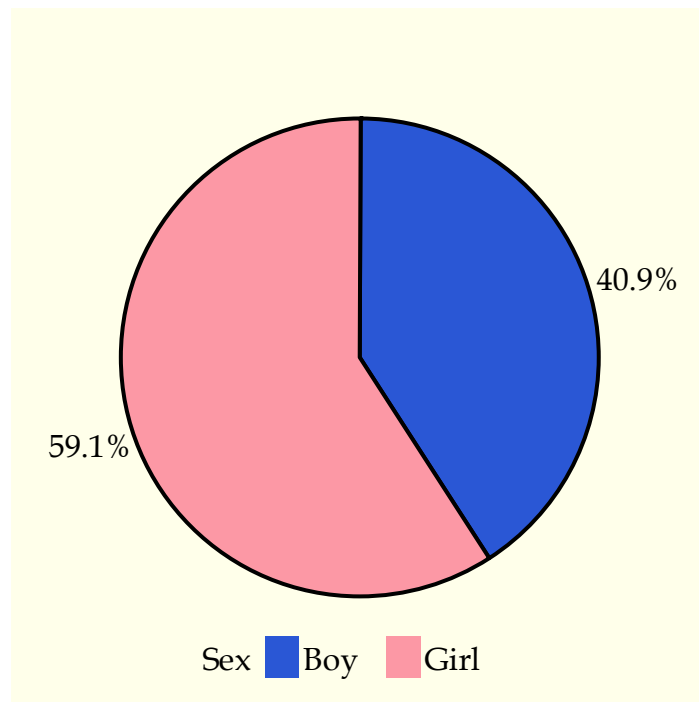


Figure 4. Frequency of boys compared to girls in all years, 1980 to 2005.

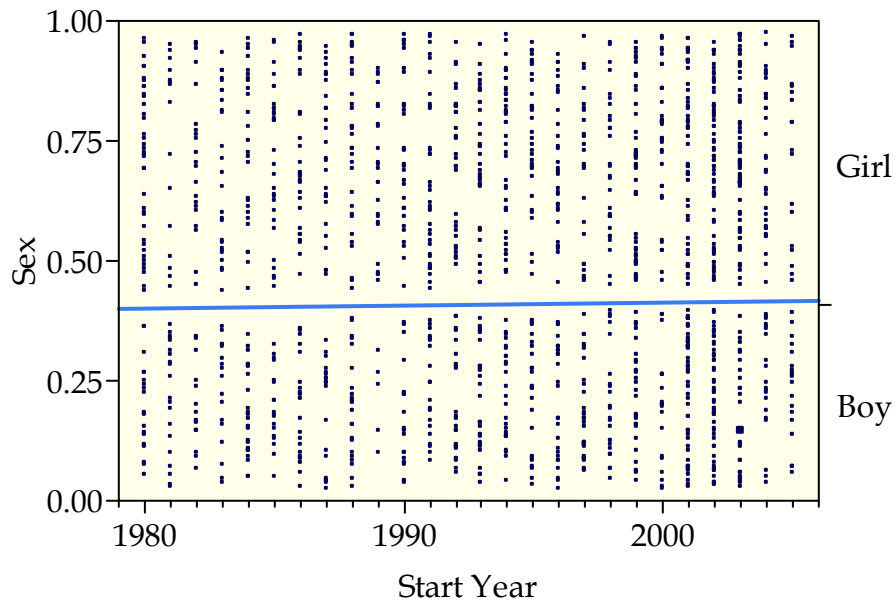


Figure 5. Plot generated by a logistic fit of sex against the year the case was started.  
 The frequencies of boys and girls have not changed significantly through time in the quarter-century interval.

Table 4. Results of logistic regression testing for a significant change in proportions of boys and girls between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	-5.3650655	14.313184	0.14	0.7078
Start Year	0.00250726	0.0071785	0.12	0.7269



## Angle Classification

For all scored cases combined ( $n = 5,255$ ), the frequency of Angle Class II cases was the most common molar relationship encountered (50%), followed by Class I cases at 41% of the total (**Figure 6**). This leaves about 9% of all scored cases exhibiting a Class III relationship (8.6%;  $n = 454$ ). This is substantially different from proportions found in the general population where 53% of children are Angle Class I molar, 32% are Class II, and 14% are Class III (Kelly and Harvey 1977).

Over the 26 years surveyed, the ratio of patients' Angle classification has changed significantly. Comparatively, more Class I patients, as compared to Class II patients, are being treated over time ( $X^2 = 52.7$ ;  $P < 0.0001$ ; **Figure 7**; **Table 5**). However, this is not true when comparing Angle Class I and III patients where there is no significant change over time ( $X^2 = 0.29$ ;  $P = 0.59$ ; **Figure 8**, **Table 6**). When Class IIs are compared to Class IIIs there is a significant increase of the Class IIIs over the surveyed time ( $X^2 = 4.19$ ;  $P < 0.04$ ) as shown in **Figure 9**, **Table 7**.

Over the 26 years surveyed, the ratio of patients' Angle classification has changed significantly. Comparatively, more Class I patients, as compared to Class II patients, are being treated over time ( $X^2 = 52.7$ ;  $P < 0.0001$ , **Figure 7**; **Table 5**). However, this is not true when comparing Angle Class I and III patients where there is no significant change over time ( $X^2 = 0.29$ ;  $P = 0.59$ ;

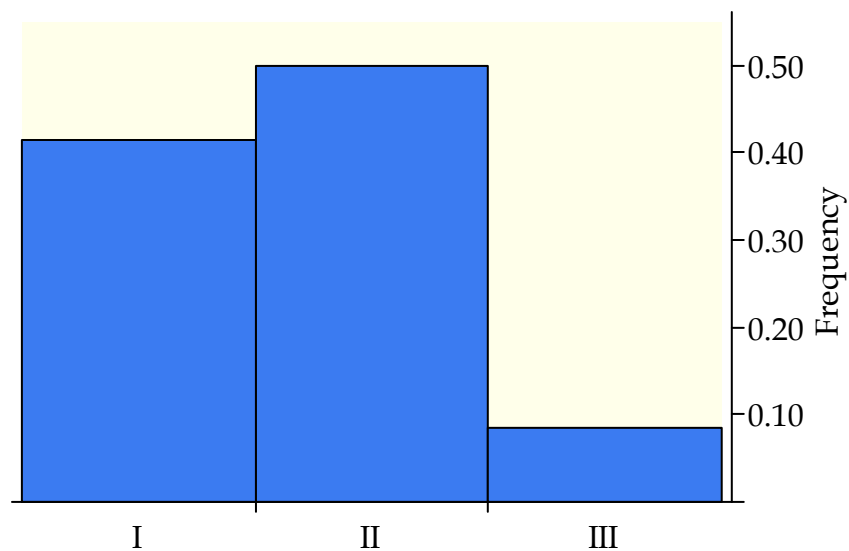


Figure 6. Frequency of molar classification (Angle) in all patients ( $n = 5,255$ ).

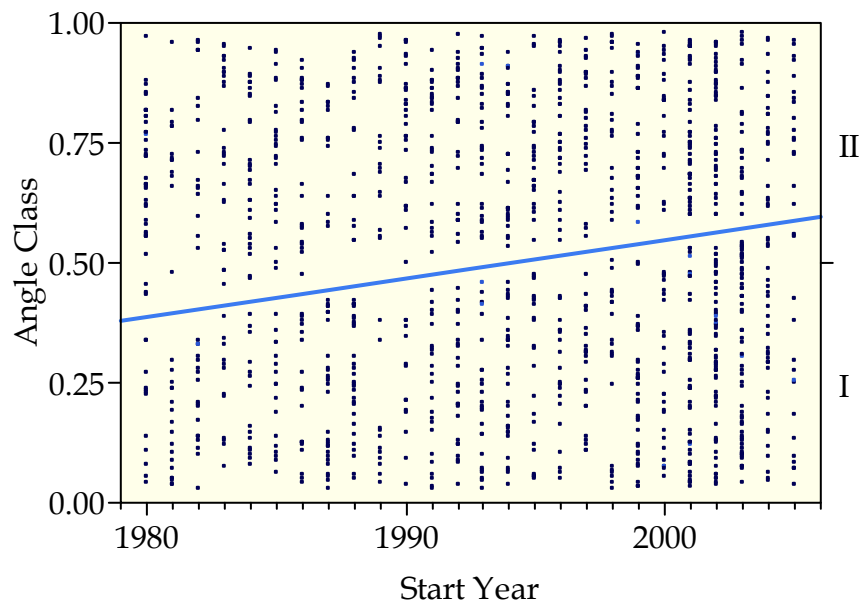


Figure 7. Plot generated by a logistic fit of Angle Class I and II cases against the year the case was started. The frequencies of Class I cases compared to Class II cases increased significantly through time in the quarter-century interval.

Table 5. Results of logistic regression testing for a significant change in proportions of Angle Class I and II patients between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	64.636173	15.106201	18.31	<0.0001
Start Year	0.03241414	0.0075759	18.31	<0.0001

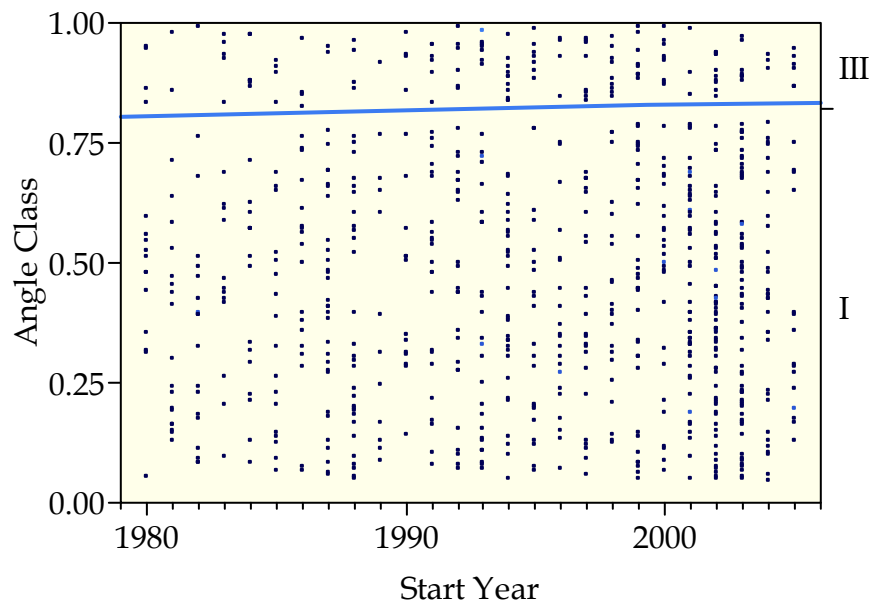


Figure 8. Plot generated by a logistic fit of Angle Class I and III cases against the year the case was started.

The frequencies of Class I cases compared to Class III cases has not significantly changed through time in the quarter-century interval.

Table 6. Results of logistic regression testing for a significant change in proportions of Angle Class I and III patients between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	-13.84127	25.521185	0.29	0.5876
Start Year	0.00770709	0.0127959	0.36	0.5470

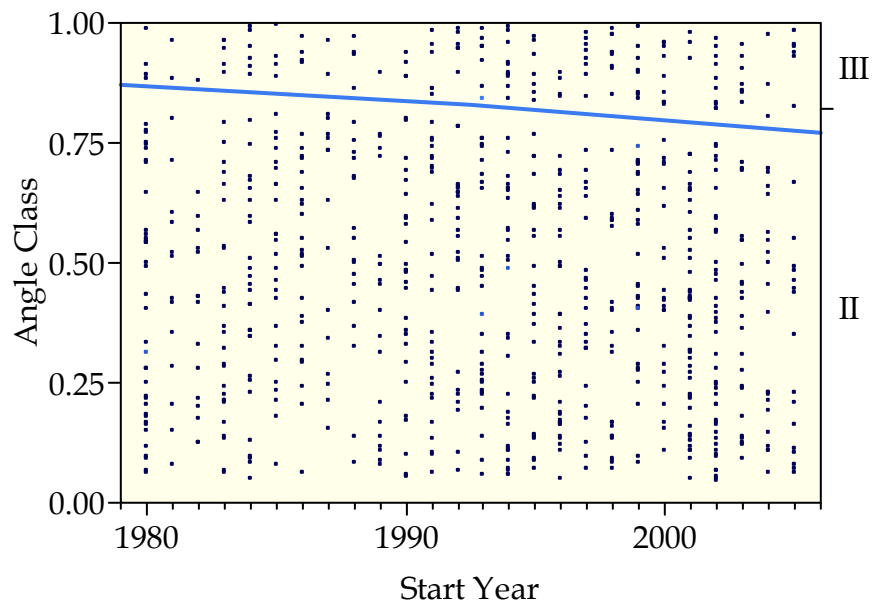


Figure 9. Plot generated by a logistic fit of Angle Class II and III cases against the year the case was started.

The frequencies of Class III cases compared to Class II cases increased significantly through time in the quarter-century interval.

Table 7. Results of logistic regression testing for a significant change in proportions of Angle Class II and III patients between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	52.8988828	25.857154	4.19	0.0408
Start Year	-0.0257623	0.0129663	3.95	0.0469

**Figure 8; Table 6).** When Class IIs are compared to Class IIIs there is a significant increase of the Class IIIs over the surveyed time ( $X^2 = 4.19$ ;  $P < 0.04$ ) as shown in **Figure 9, Table 7.**

### Angle Classification, Race, and Sex

Studies of non-orthodontic samples of Americans report higher frequencies of Class III molar relationships among Blacks (Kelly and Harvey 1977). This race difference is also mirrored here. The Black-White differences in molar relation are highly significant statistically ( $X^2 = 52.7$ ;  $df = 2$ ;  $P < 0.0001$ ), and Class III cases are more common in Blacks (17%; 57/330) than in Whites (7%; 90/1,196) as shown in **Figures 10, 11, and 12.** Conversely, Class II cases are more common in Whites (51%; 608/1,196) than in Blacks (31%; 103/330), which is also seen in **Figures 10, 11, and 12.** This leaves the Class I relationship more common in Blacks (51%; 170/330) than in Whites (42%; 498/1,196). For all cases combined, Class I patients represented 41% of the sample while Class II and III represented 50% and 9% respectively (**Figure 6**). In contrast, there was no suggestion of a sex difference by Angle's molar classification either in American Blacks or in American Whites.

### Angle Classification and the FMA

It is interesting that the consequences of Angle's molar classification is different in American Blacks and Whites. When FMA was appraised as a function of Angle's classification, there is no dependence in Blacks ( $F = 1.2$ ;  $P = 0.29$ ), meaning that average FMA does not differ among Class I, II, and III. In Whites, however, the Class III sample had a significantly higher FMA than the other two categories ( $F = 3.2$ ;  $P = 0.04$ ). Average FMA was about 25 degrees in Angle Class I and II, but about 27 degrees in the Class III sample.

### Orthognathic Surgery

Only 2% of this sample (30/1,499) was treated with an orthognathic procedure. Moreover, as shown in **Figure 13 and Table 8,** the frequency of surgical procedures has decreased through time ( $P = 0.04$ ).

Malocclusions treated with surgery were about equally divided between Class II (43%) and Class III (47%) cases, but, again, the total sample size ( $n = 30$ ) is small. Sex of the patient was not an identifiable risk factor for surgery in this small sample, with a male-female split of 14:16. Predictably, the age of the

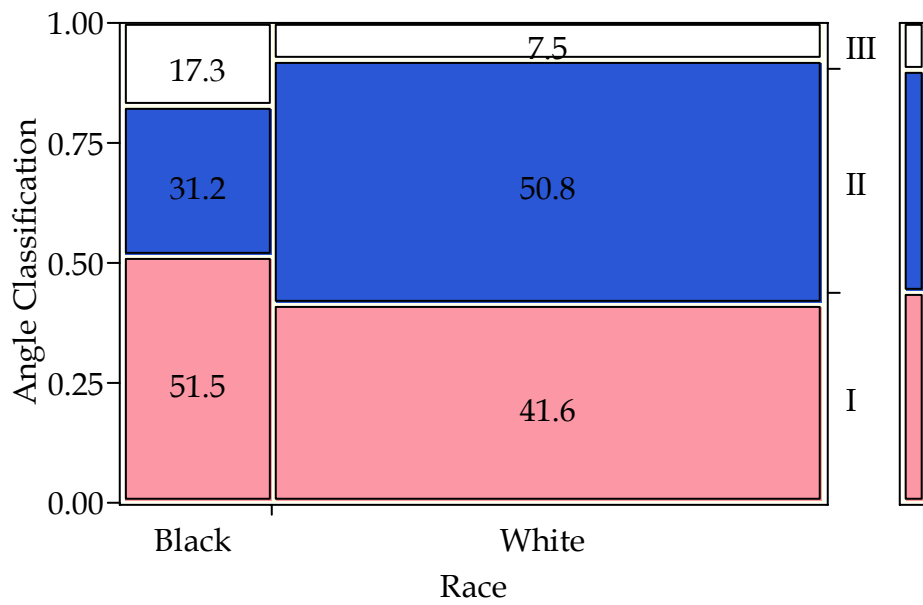


Figure 10. Mosaic chart showing percentage of Angle Class by race (as defined as Black or White).

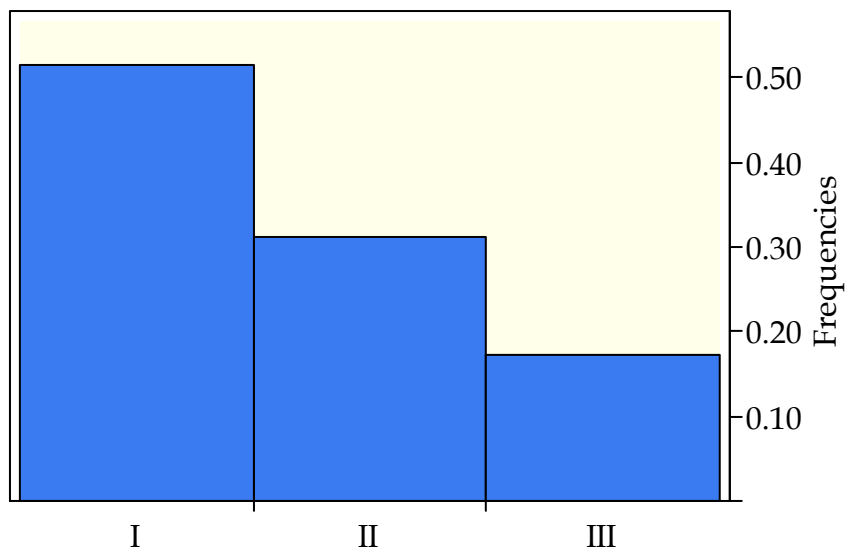


Figure 11. Frequency of molar classification (Angle) in Black patients.

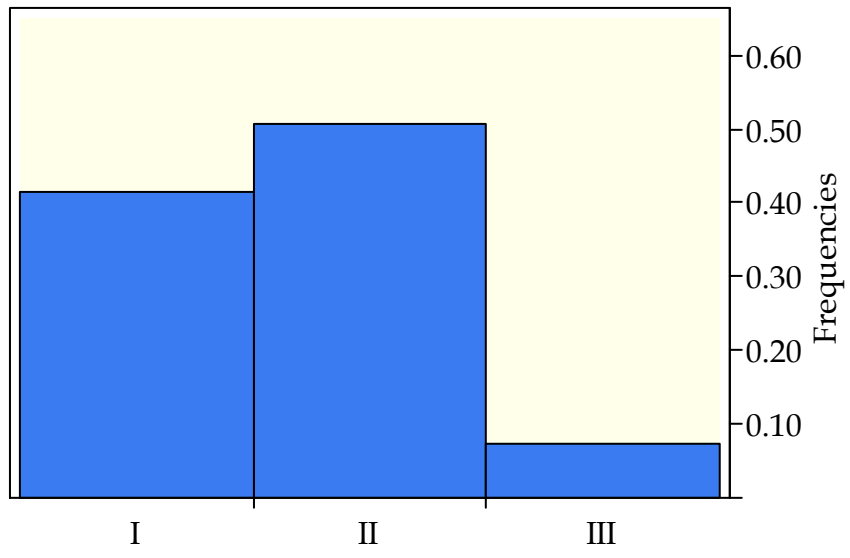


Figure 12. Frequency of molar classification (Angle) in White patients.

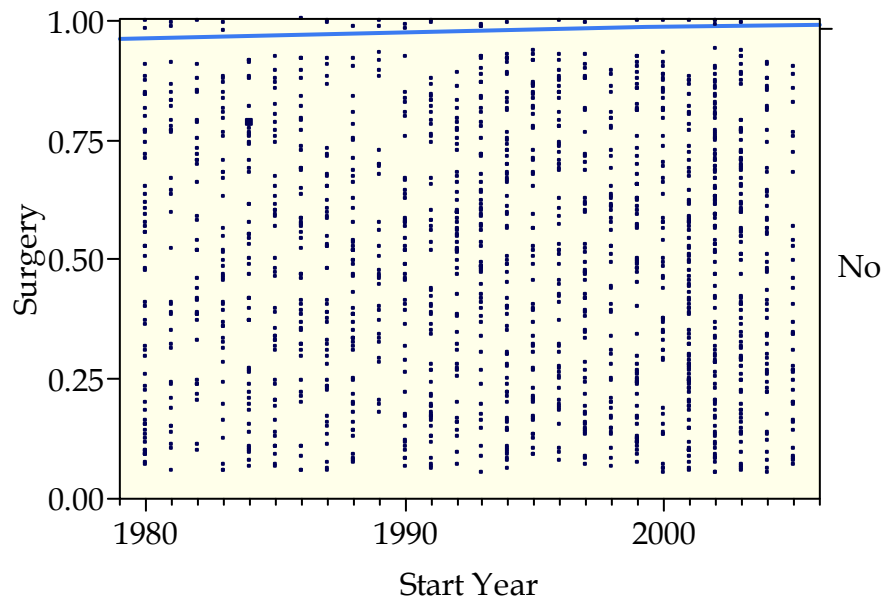


Figure 13. Plot of the frequency of surgical cases as a function of start dates. The frequency has decreased significantly over the 26 year interval recorded here.

Table 8. Results of logistic regression testing for a significant change in proportions of surgery and non-surgery patients between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	-94.229974	49.282127	3.66	0.0559
Start Year	0.0492315	0.0247503	3.96	0.0467



surgical cases ( $\bar{x}$  = 20.2 yrs) significantly exceeded that of the other orthodontic patients ( $\bar{x}$  = 15.7 yrs), since the effective cessation of growth is generally a consideration ( $F$  = 11.1;  $P$  = 0.0009).

### Age at Treatment

The backbone of most orthodontic practices is the young adolescent who has recently achieved a full permanent dentition, and that is the case here (**Figure 14**). The mean age at the start of treatment for the total sample is 15.8 years – with a large standard deviation ( $sd$  = 7.4 years). Younger cases consist of children with facial clefts or with craniofacial syndromes in whom treatment began soon after birth. The preadolescent segment consists of children receiving early treatment in the mixed dentition. The age distribution also is decidedly positively skewed, which reflects the older segment of the adult population now seeking orthodontic treatment.

The mean age of child and adolescent patients seeking treatment (patients age 6 to 17) is 13.4 years with a standard deviation of 1.9 years. The distribution of these patients is shown in **Figure 15**. Although there are younger patients, 6 years old was chosen as the lower end of the child and adolescent group because it is likely that these children are being treated orthodontically, with early treatment. The youngest children were excluded here because they are likely to be treated for cleft palate or branchial arch syndromes.

Adult patients, those 18 years old and older, had a mean age of 30.1 years with a standard deviation of 9.4. The oldest patient treated was 66 years old and the distribution of these patients is shown in **Figure 16**.

Over the time interval there was a significant increase in the age of patients at the start of treatment ( $P$  = 0.0003; **Figure 17, Table 9**). This trend reflects the fact that more adults are seeking orthodontic treatment as time goes forward.

### Treatment Mechanics

Treatment mechanics at the University consist of three categories: Begg mechanics, standard edgewise mechanics, and straight-wire edgewise mechanics. Begg treatment was discontinued in 1999, whereas both standard edgewise mechanics and straight-wire edgewise mechanics were used in the clinic throughout the quarter-century surveyed. Information about mechanics was available for 1,454 patients. Overall, the patients were treated with Begg

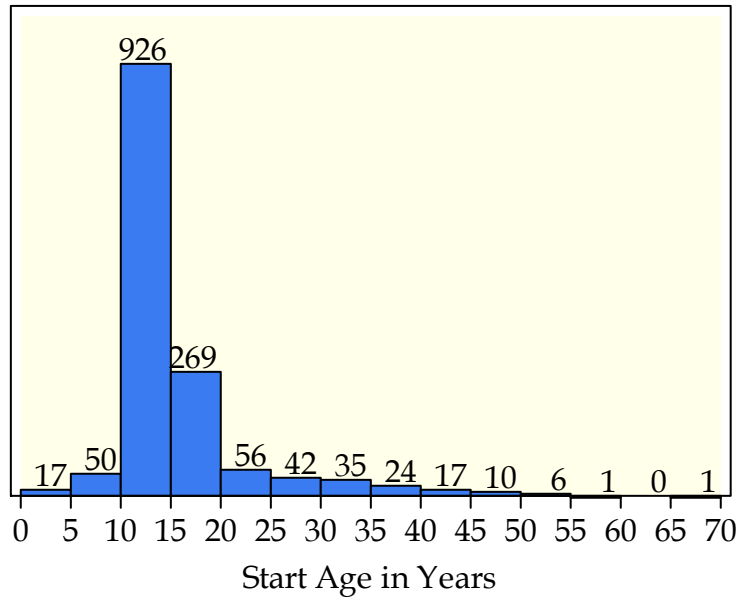


Figure 14. Plot of ages at the start of treatment (years) for all patients in the sample.  
The vertical axis is counts of the cases (sexes and races pooled).

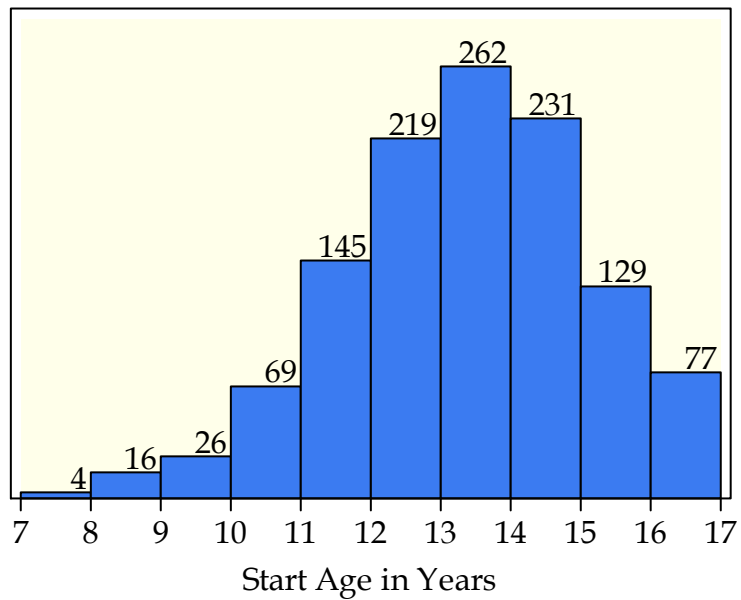


Figure 15. Plot of ages at the start of treatment (years) for patients age 6 to 17 (sexes and races pooled).

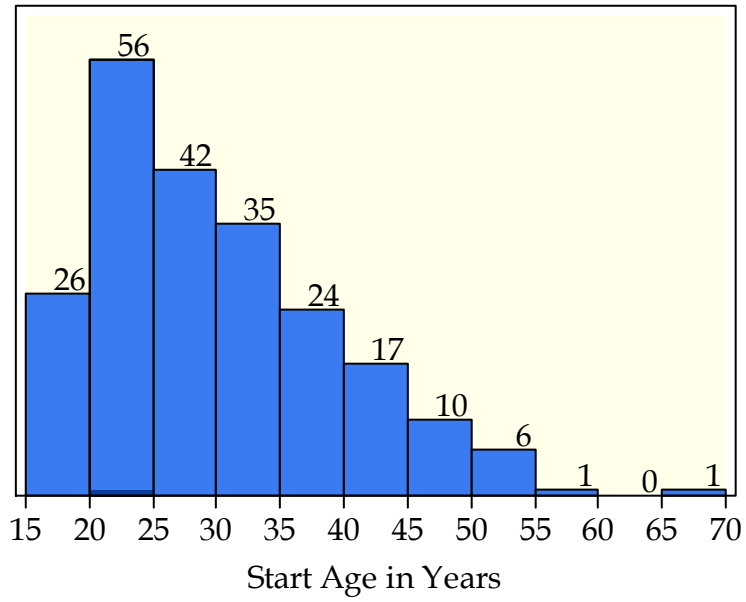


Figure 16. Plot of ages at the start of treatment (years) for patients age 18 and older (sexes and races pooled).

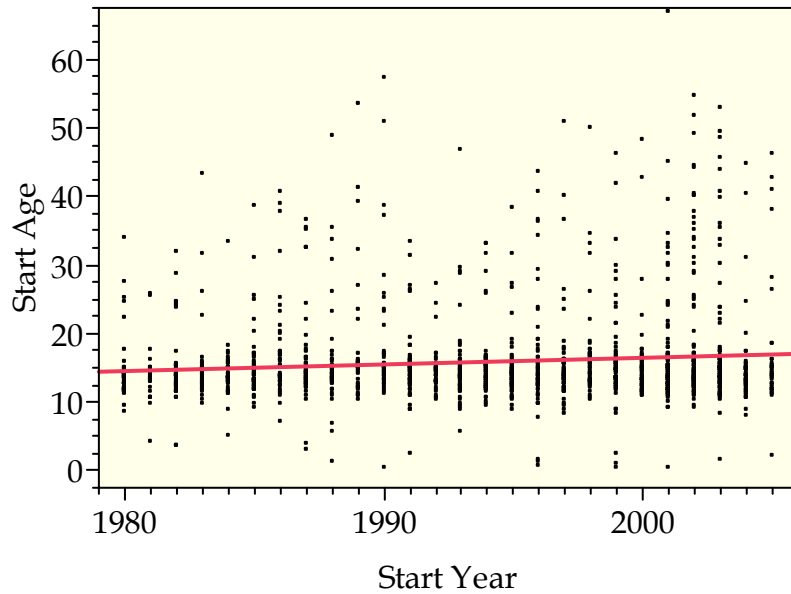


Figure 17. Plot generated by bivariate fit between the year of case start against patient start age for all cases. Average patient start age has significantly increased over the interval studied, reflecting the increase in adult patients seeking treatment:  $\text{Start Age} = -174.85 + 0.10(\text{Start Year})$ .

Table 9. Results of bivariate fit testing for a significant change in the start age over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	-174.8498	52.21472	-3.35	0.0008
Start Year	0.0956165	0.026186	3.65	0.0003

mechanics in 18% of cases, with standard edgewise in 38% of cases, and with straight-wire edgewise in 44% of cases (**Figure 18**).

As expected with a cessation of a treatment modality, the ratio of cases treated by type of mechanics changed. The frequency of Begg mechanics declined from being the most common type of treatment mechanics in the early eighties to eventually dying out in the late nineties. Over this time period the percentage of straight-wire edgewise and standard edgewise each increased to roughly 50% of the cases treated. Excluding the Begg cases from analysis, the overall distribution of cases is 53% straight-wire edgewise mechanics and 47% standard edgewise mechanics (**Figure 19**).

Using logistic regression, the ratio of standard edgewise mechanics to straight-wire edgewise mechanics did not significantly change over time ( $X^2 = 0.02$ ;  $P = 0.90$ ), as seen in **Figure 20, Table 10**. However, as Begg mechanics declined, there was a proportionate increase in the practice of standard edgewise and straight-wire edgewise in the University clinic (**Figure 21, Table 11, and Figure 22, Table 12**, respectively).

### Extraction Frequency

Extraction data were available for 1,439 patients treated from 1980 to 2005. Of these, 55% were treated with extractions while 45% were treated non-extraction. As shown in **Figure 23, Table 13**, the overall frequency of extraction treatment for all mechanics has significantly decreased over time ( $X^2 = 42.0$ ;  $P < 0.0001$ ).

Each type of treatment mechanics, when considered individually, also showed a decrease in frequency of extractions over time: Begg ( $X^2 = 6.73$ ;  $P = <0.0095$ ; **Figure 24, Table 14**), standard edgewise ( $X^2 = 19.95$ ;  $P < 0.0001$ ; **Figure 25, Table 15**), and straight-wire edgewise ( $X^2 = 7.23$ ;  $P < 0.0072$ ; **Figure 26, Table 16**). The decrease in extraction frequency reflects a national trend, and there are several contributory causes towards non-extraction treatment.

As shown in **Figure 27, Table 17, and in Figure 28, Table 18**), when standard edgewise and straight-wire edgewise cases are compiled, both four-premolar and two-premolar extraction cases significantly decrease over time compared to non-extraction cases ( $X^2 = 28.4$ ;  $P < 0.0001$ ;  $X^2 = 20.9$ ;  $P < 0.0001$ ). When four-premolar and two-premolar extraction cases are compared over the 26 year interval, there are no significant differences found ( $X^2 = 1.19$ ;  $P < 0.27$ ; **Figure 29, Table 19**).

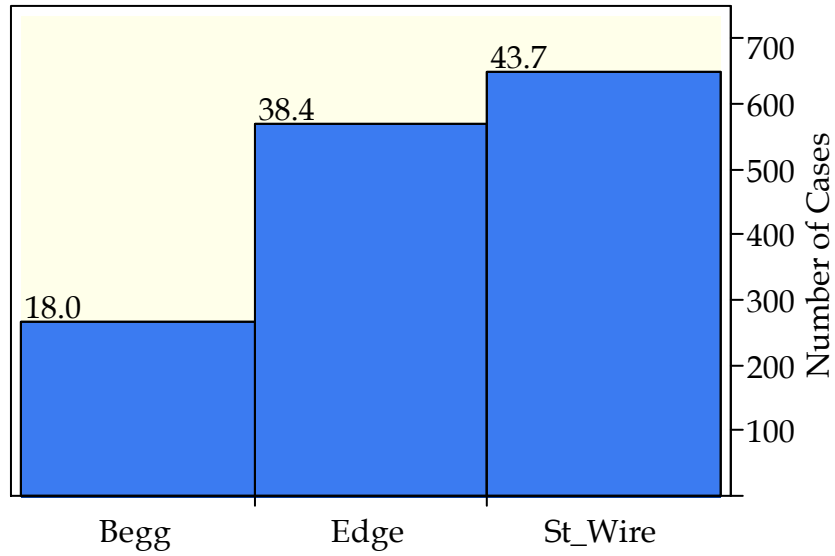


Figure 18. Histogram showing the number of cases treated with Begg, standard edgewise and straight-wire edgewise mechanics over the 26 years surveyed. Percentages are shown on top of the bars.

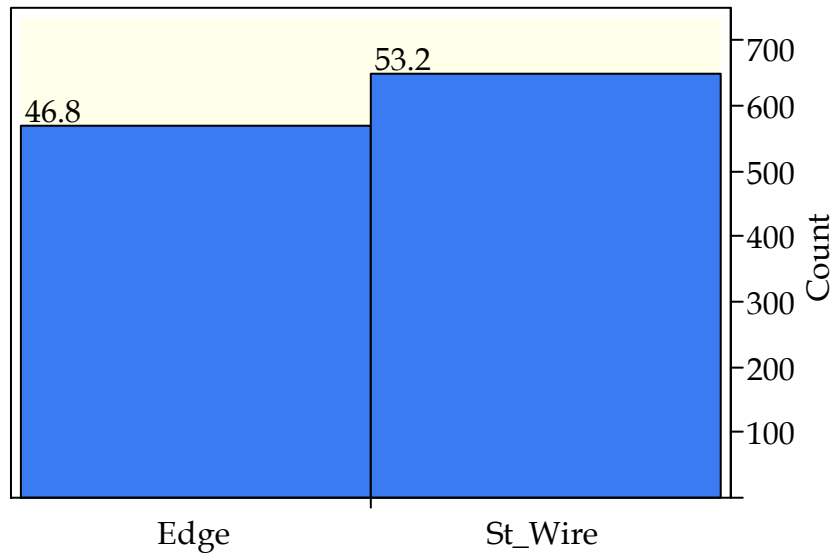


Figure 19. Histogram showing the number of cases treated with standard edgewise and straight-wire edgewise mechanics only (excluding Begg) over the 26 years surveyed. Percentages are shown on top of the bars.

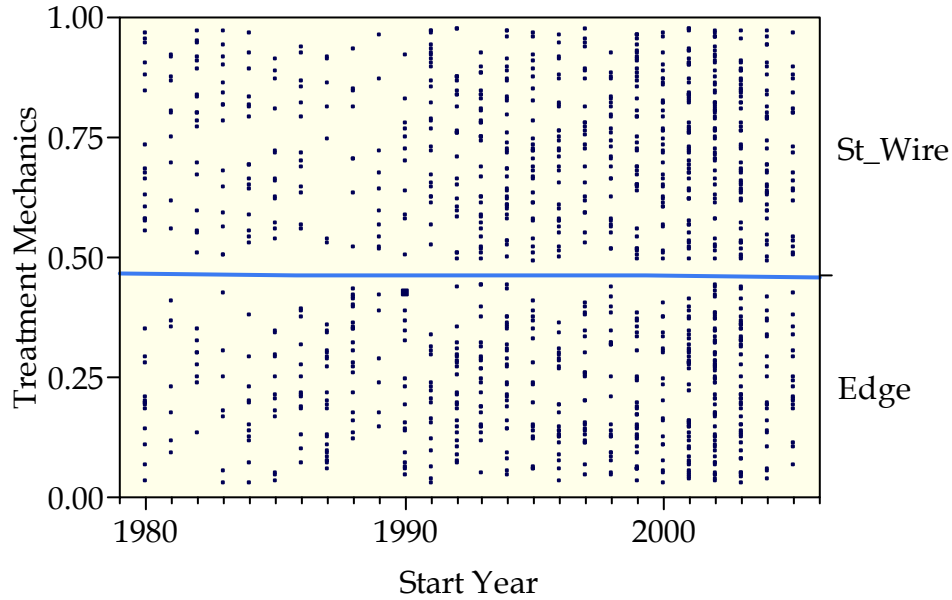


Figure 20. Plot generated by logistic analysis of treatment mechanics (standard edgewise, straight-wire) against the year the case was started. Excluding Begg mechanics, the ratio of treatment mechanics has not significantly changed through time in the quarter-century interval.

Table 10. Results of logistic regression testing for a significant change in proportions of treatment mechanics for standard edgewise and straight-wire edgewise cases treated between 1980 and 2005.

Term	Estimate	sem	X <sup>2</sup>	P-value
Intercept	1.9688136	16.758991	0.01	0.9065
Start Year	-0.0010636	0.0083983	0.02	0.8992

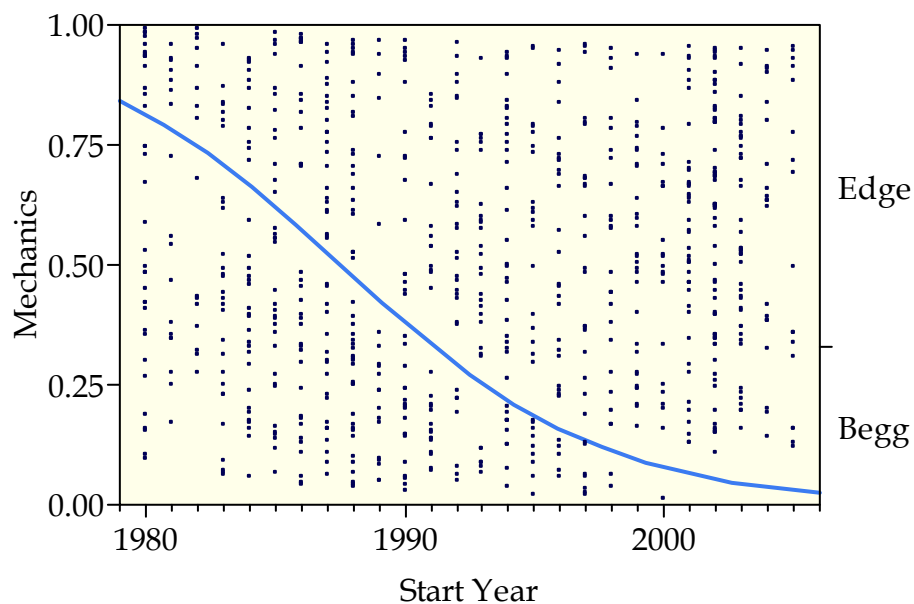


Figure 21. Plot generated by logistic analysis of treatment mechanics (Begg, standard edgewise) against the year the case was started. The frequencies of treatment mechanics have significantly changed through time in the quarter-century interval.

Table 11. Results of logistic regression testing for a significant change in proportions of treatment mechanics for Begg and standard edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	393.67	29.930274	173.00	<0.0001
Start Year	-0.20	0.0150421	173.40	<0.0001



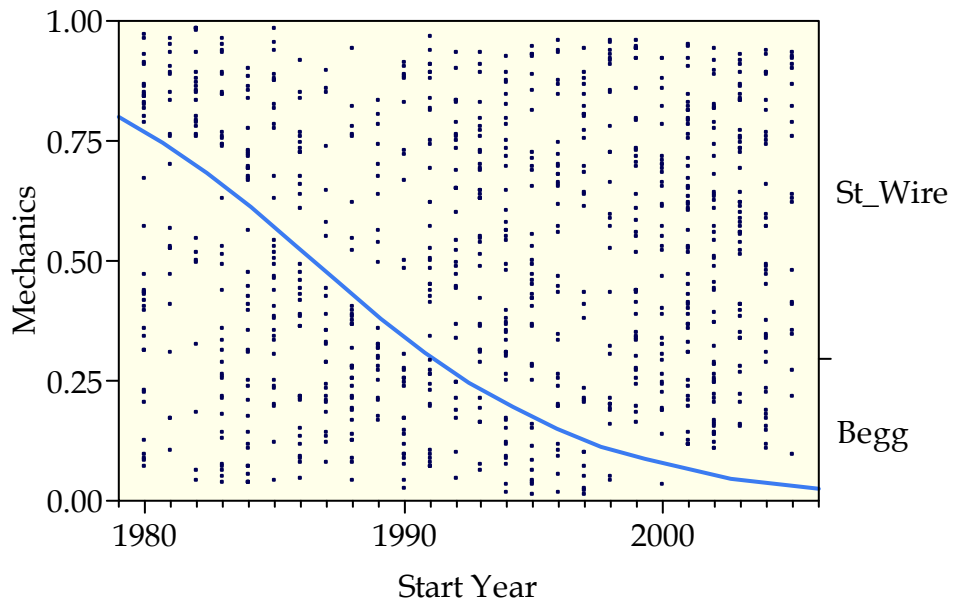


Figure 22. Plot generated by logistic analysis of treatment mechanics (Begg, straight-wire) against the year the case was started. The frequencies of treatment mechanics have significantly changed through time in the quarter-century interval.

Table 12. Results of logistic regression testing for a significant change in proportions of treatment mechanics for Begg and straight-wire edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	$\chi^2$	P-value
Intercept	368.760545	27.24806	183.15	<0.0001
Start Year	-0.1856322	0.0136945	183.74	<0.0001

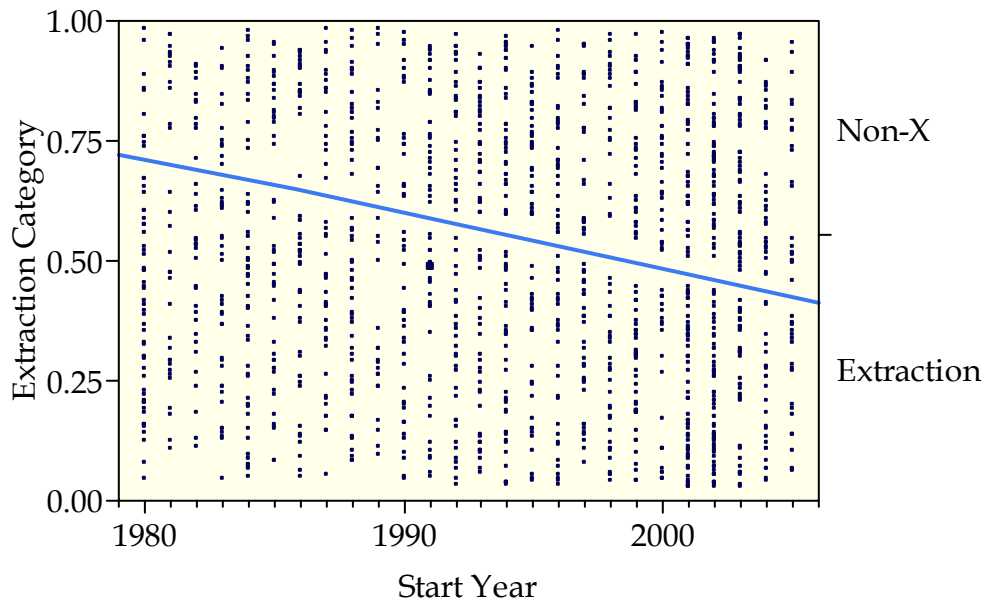


Figure 23. Plot generated by logistic analysis of extraction category against the year the case was started for all cases. The frequency of extraction cases has significantly decreased over time in the quarter-century interval.

Table 13. Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for all cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	96.170574	14.807837	42.18	<0.0001
Start Year	-0.0481198	0.0074252	42.00	<0.0001

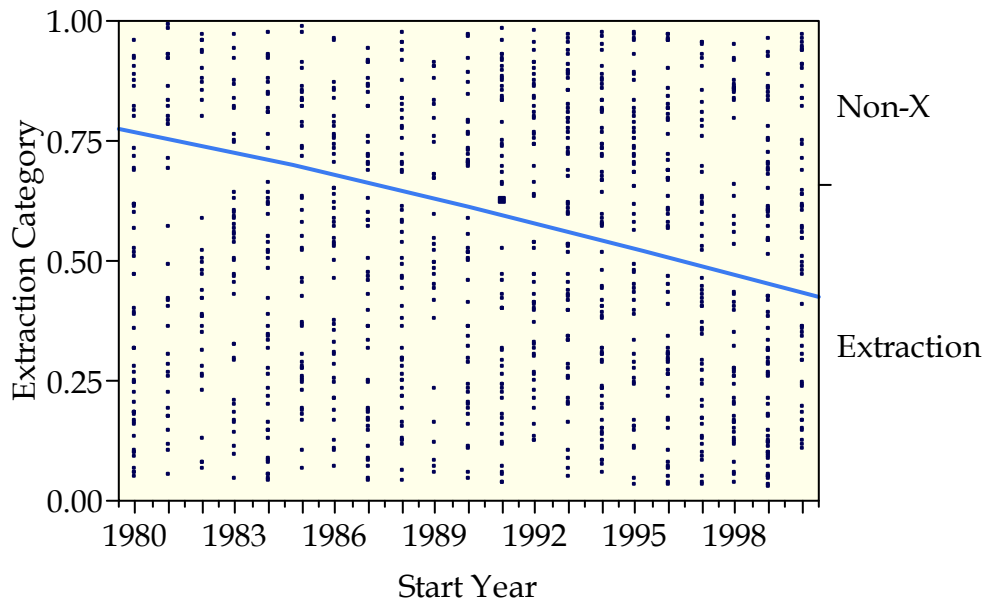


Figure 24. Plot generated by logistic analysis of extraction category against the year the case was started for Begg mechanics only. The frequency of extraction cases has significantly decreased over time in the quarter-century interval.

Table 14. Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for Begg cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	146.963311	56.38589	6.79	0.0092
Start Year	-0.0736175	0.0283669	6.73	0.0095

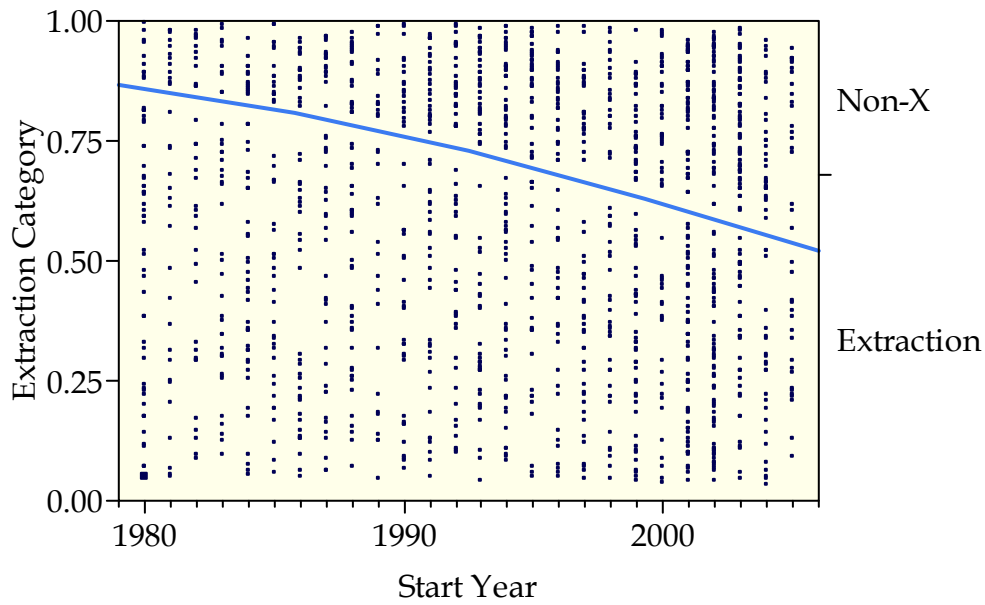


Figure 25. Plot generated by logistic analysis of extraction category against the year the case was started for standard edgewise mechanics only. The frequency of extraction cases has significantly decreased over time in the quarter-century interval.

Table 15. Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for standard edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	$\chi^2$	P-value
Intercept	133.46827	29.725589	20.16	<0.0001
Start Year	-0.0664906	0.0148873	19.95	<0.0001

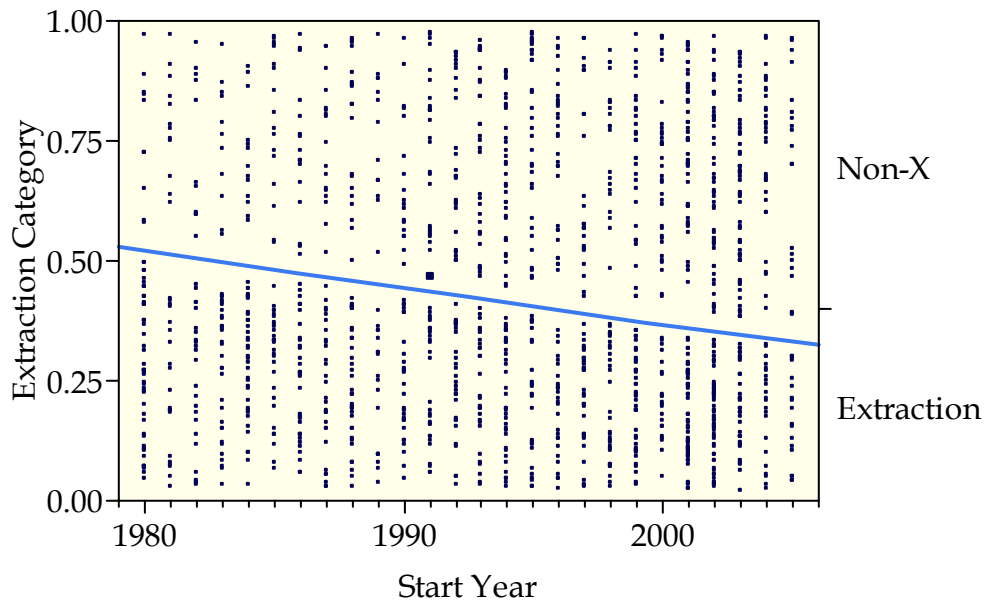


Figure 26. Plot generated by logistic analysis of extraction category against the year the case was started for straight-wire edgewise mechanics only. The frequency of extraction cases has significantly decreased over time in the quarter-century interval.

Table 16. Results of logistic regression testing for a significant change in proportions of extraction and non-extraction for straight-wire edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	$\chi^2$	P-value
Intercept	62.1492066	23.268033	7.13	0.0076
Start Year	-0.0313465	0.0116611	7.23	0.0072

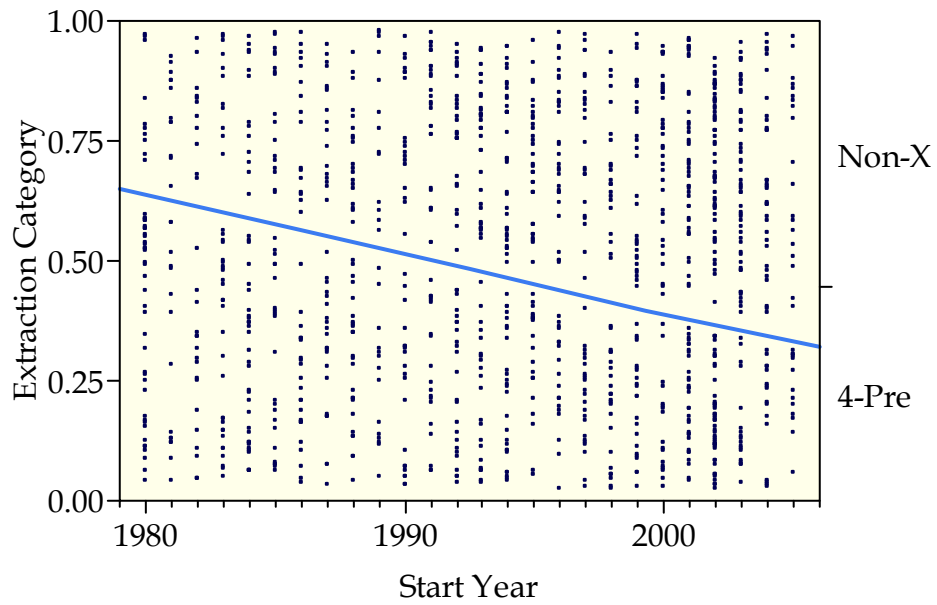


Figure 27. Plot generated by logistic analysis of extraction category (Non-X, 4-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics.

The frequency of 4 premolar extraction cases has significantly decreased compared to non extraction cases over time in the quarter-century interval.

Table 17. Results of logistic regression testing for a significant change in proportions of four premolar extraction and non-extraction for all edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	100.800518	18.917202	28.39	<0.0001
Start Year	-0.0506265	0.0094803	28.52	<0.0001

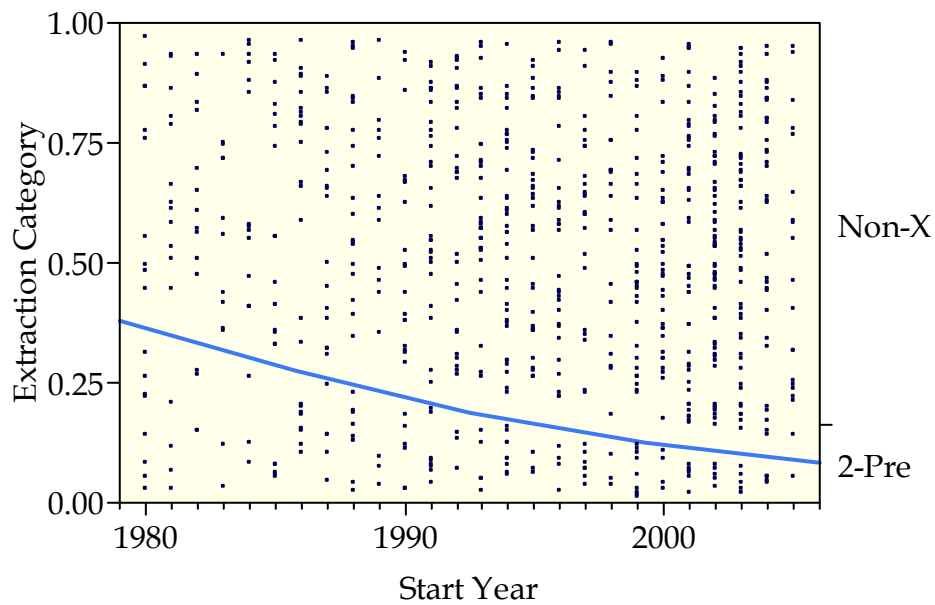


Figure 28. Plot generated by logistic analysis of extraction category (Non-X, 2-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics.

The frequency of 2 premolar extraction cases has significantly decreased compared to non-extraction cases over time in the quarter-century interval.

Table 18. Results of logistic regression testing for a significant change in proportions of two premolar extraction and non-extraction for all edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	140.991814	30.83236	20.91	<0.0001
Start Year	-0.0714939	0.0154623	21.38	<0.0001

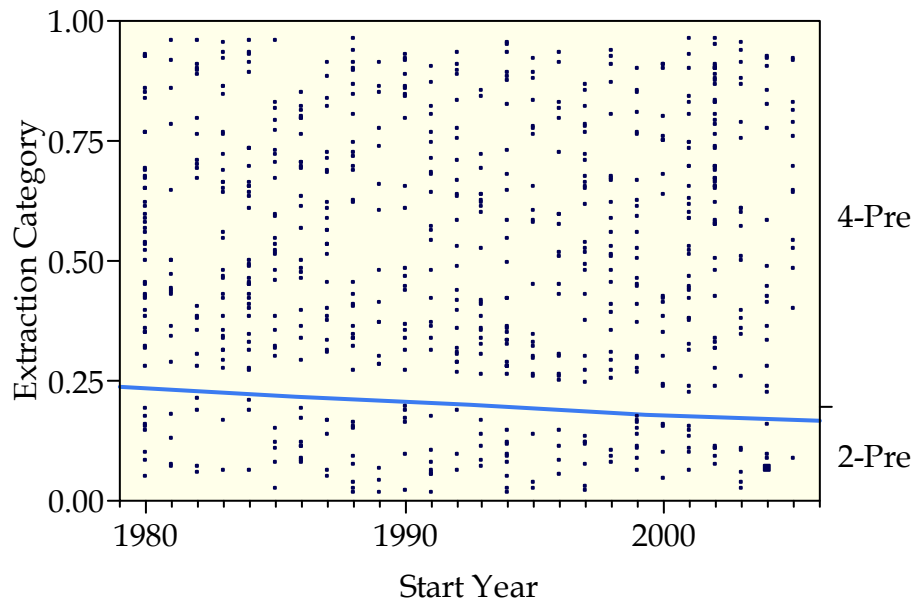


Figure 29. Plot generated by logistic analysis of extraction category (4-Pre, 2-Pre) against the year the case was started for standard edgewise and straight-wire edgewise mechanics.

The frequency of 4 premolar extraction cases has not significantly changed compared to 2 premolar extraction cases over time in the quarter-century interval.

Table 19. Results of logistic regression testing for a significant change in proportions of four premolar extraction and two premolar extraction for all edgewise cases treated between 1980 and 2005.

Term	Estimate	Sem	$\chi^2$	P-value
Intercept	31.7647817	29.139482	1.19	0.2757
Start Year	-0.0166434	0.0146171	1.30	0.2549



A significant difference in extraction rates exists for each Angle classification ( $X^2 = 14.8$ ; 2 df;  $P < 0.0006$ ). Over the surveyed time, 52% of Class I cases, 60% of Class II cases, and 46% of Class III cases were treated with extractions (**Figure 30**).

### TennCare Utilization

Data on TennCare utilization was available on 1,496 patients. Approximately 5% of all patients were subsidized for treatment by the State of Tennessee's Medicare program called TennCare. To qualify for subsidized treatment, patients have to be enrolled in the TennCare program, be under the age of 21 at the start of treatment, and score a 28 or higher on the Salzmann Handicapping Malocclusion Index (Salzmann 1968). According to the data, TennCare cases have significantly increased over the quarter century interval surveyed ( $X^2 = 31.3$ ;  $P < 0.0001$ ; **Figure 31, Table 20**). This probably is due to a combination of causes. Patient charts became much more informative and consistent in the late 1990s and documentation on TennCare patients increased dramatically. Furthermore, a faculty member in the department was added to the TennCare provider list in 1999, whereas, previously, a school administrator (a general dentist) had been on the provider list and referred patients at his discretion.

TennCare patients also significantly increased from 2000 to 2005 ( $X^2 = 4.38$ ;  $P < 0.036$ ), and during that six year span, 9% of patients were subsidized by TennCare (**Figure 32, Table 21**). This increase in TennCare patients could be explained by word of mouth among TennCare families and an increase in referrals from TennCare dentists.

### ANB Angle

The average ANB angle over all cases measured ( $n = 1,483$ ) is 3.6 degrees with a standard deviation of 3.0 and a range from -13 to 19 degrees. **Figure 33** shows the distribution of all patients' ANB angles over the time surveyed.

Patients' ANB angles have not changed significantly over time, as a whole, or when divided into groups based on race (**Figure 34, Table 22**).

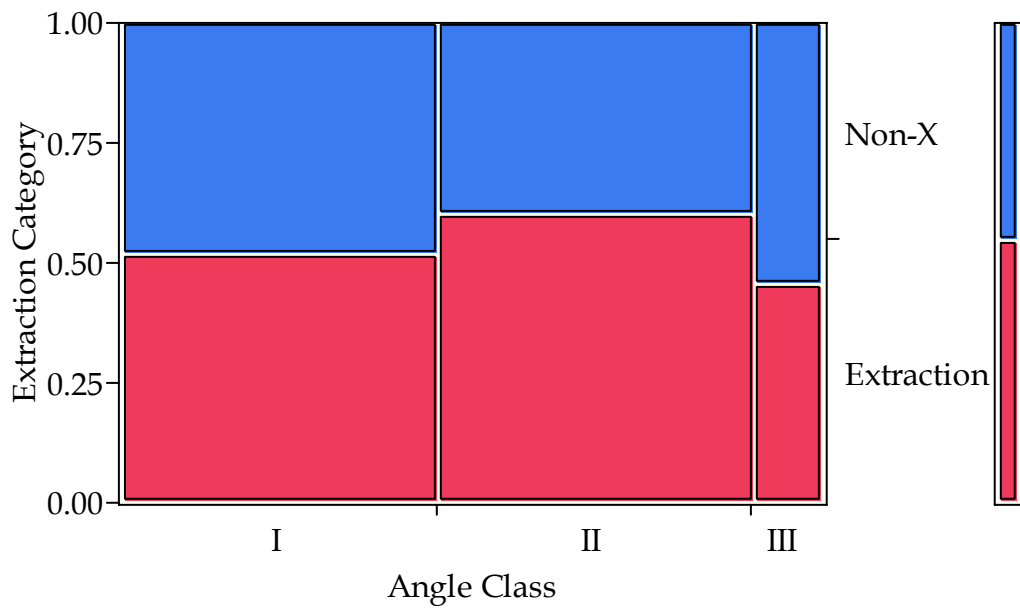


Figure 30. Mosaic plot showing frequency of extraction by Angle classification. A significant difference in extraction frequency exists for each Angle Class.

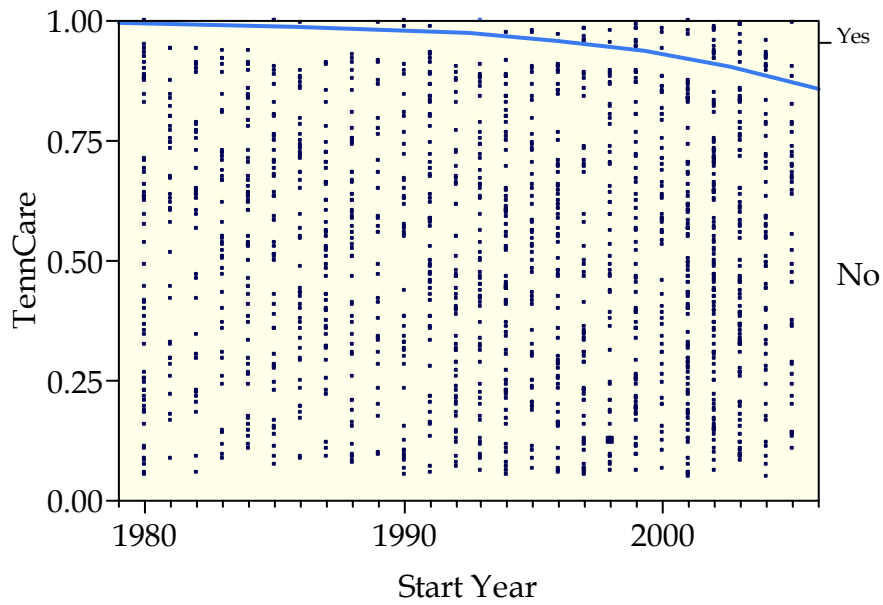


Figure 31. Plot generated by logistic analysis of whether or not a patient had TennCare against the year the case was started for all years. The frequency of TennCare cases appears to have significantly increased over time, although whether or not more TennCare patients were actually treated is difficult to determine due to possible charting differences in the last 26 years.

Table 20. Results of logistic regression testing for a significant change in proportions of TennCare cases and non-TennCare cases treated between 1980 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	268.508534	47.506829	31.95	<0.0001
Start Year	-0.1329609	0.0237658	31.30	<0.0001

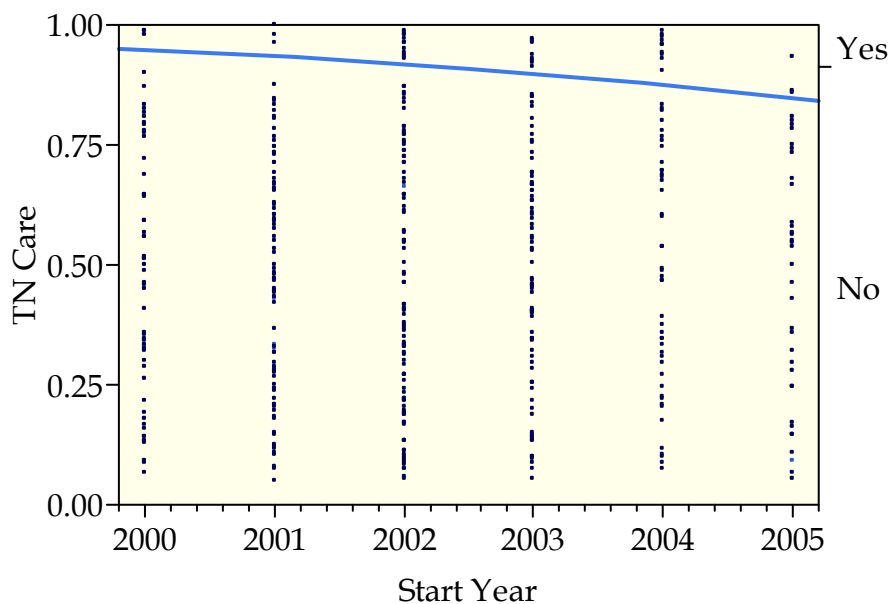


Figure 32. Plot generated by logistic analysis of whether or not a patient had TennCare against the year the case was started for 2000 to 2005. The frequency of TennCare cases significantly increased over this time, perhaps because of better record keeping.

Table 21. Results of logistic regression testing for a significant change in proportions of TennCare cases and non-TennCare cases treated between 2000 and 2005.

Term	Estimate	Sem	X <sup>2</sup>	P-value
Intercept	483.149649	229.87852	4.42	0.0356
Start Year	-0.2401183	0.1147861	4.38	0.0364

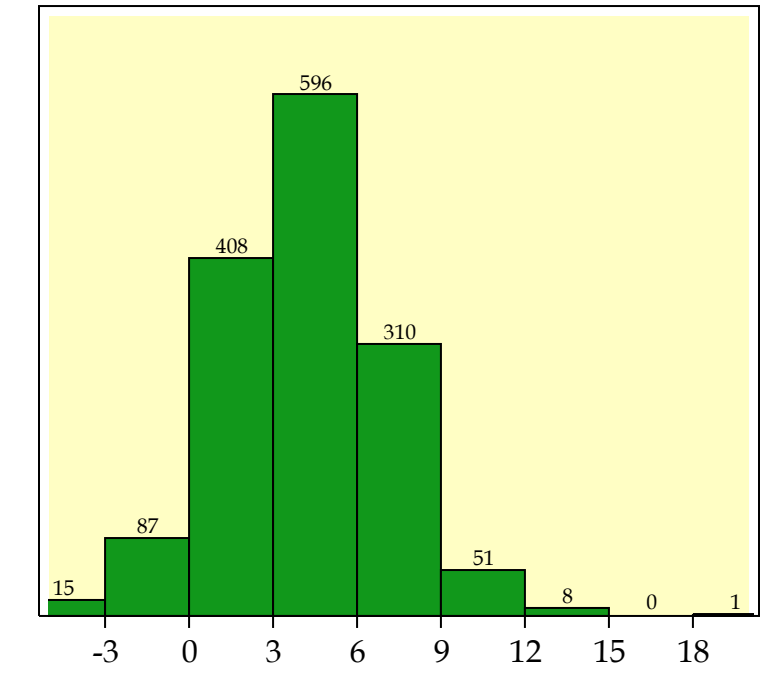


Figure 33. Histogram showing the distribution of ANB angles in the quarter-century surveyed. ANB (angle) is shown along the horizontal axis, based on all cases scored (n = 1,483).

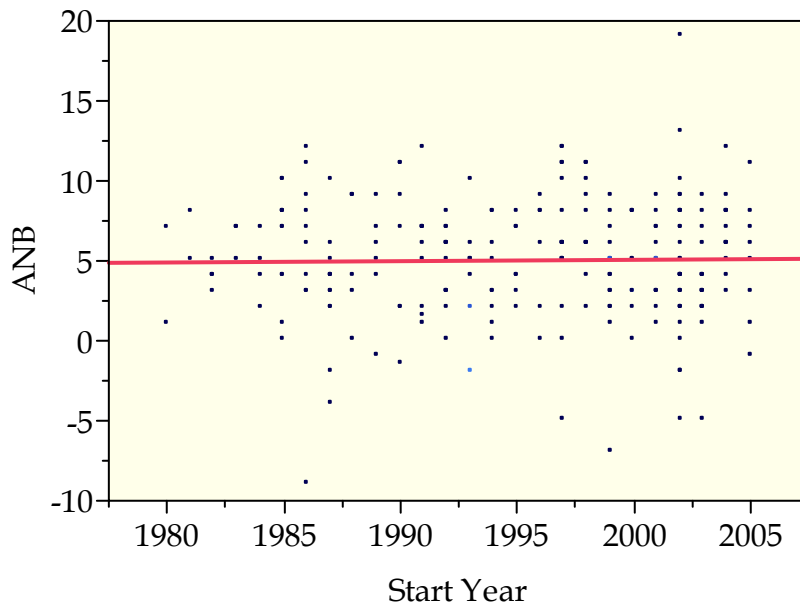


Figure 34. Plot generated by bivariate fit of ANB angle by start year for all cases. The average ANB angle has not significantly changed from 1980 to 2005.

Table 22. Results of bivariate fit testing for a significant change in the ANB angle over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	6.432219	21.30936	0.30	0.7628
Start Year	-0.001447	0.01068	-0.14	0.8923

### Frankfort Mandibular Plane Angle

The mean FMA is 25.9 degrees with a standard deviation of 6.1 degrees and a range of 6 degrees to 48 degrees. **Figure 35** shows the distribution of the FMAs of all patients treated in the time surveyed.

When all patients are pooled, average FMA has significantly decreased over the surveyed interval (**Figure 36, Table 23**). When grouped into White, Black, and “other” groups, only the White patients show a significant change in FMA, which significantly decreased (**Figure 37, Table 24; Figure 38, Table 25; and Figure 39, Table 26**, respectively). The reason for this decrease in FMA over time is unknown, but may be due to changes in how Porion or other lateral cephalogram landmarks are traced.

### Duration of Treatment

The average duration of treatment over the quarter-century surveyed is 2.5 years (sd = 1.2 years) for all cases, 2.8 years (sd = 1.3 years) for Begg cases, 2.3 years (sd = 1.0 years) for standard edgewise cases, and 2.5 years (sd = 1.2 years) for straight-wire cases (**Figure 40**). Using one-way ANOVA and Tukey-Kramer HSD post-hoc analysis, it was found that these mean treatment times were significantly different from one another ( $F = 15.4; P < 0.0001$ ). That is, even though the means are similar, the sample sizes are so large that small differences are detected statistically. Edgewise treatment, with the shortest mean treatment time is significantly different from straight-wire with an intermediate time, and Begg treatment with the longest mean treatment time significantly exceeding mean treatment time for the straight-wire group. These treatment times involve many operators over several years, so the highly significant differences are somewhat surprising. On the other hand, results may be different in the private orthodontists’ offices outside this teaching environment.

Treatment duration for all cases combined decreased over the 26 year period studied (**Figure 41, Table 27**). When Begg cases were looked at as an individual group, treatment time did not significantly change (**Figure 42, Table 28**), but when standard edgewise cases and straight-wire edgewise cases were looked at as separate groups (**Figure 43, Table 29 and Figure 44, Table 30**), treatment time decreased significantly.

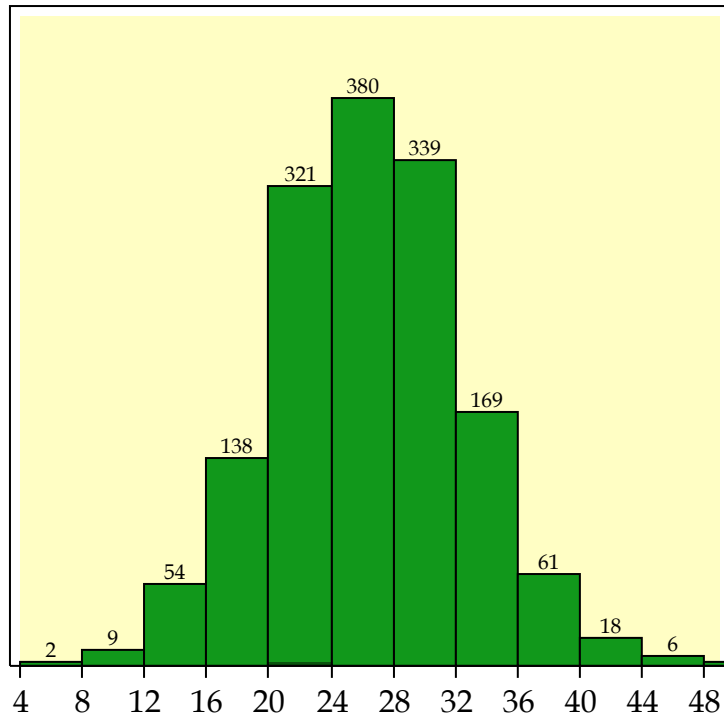


Figure 35. Histogram showing the distribution of the FMA in the quarter-century surveyed.



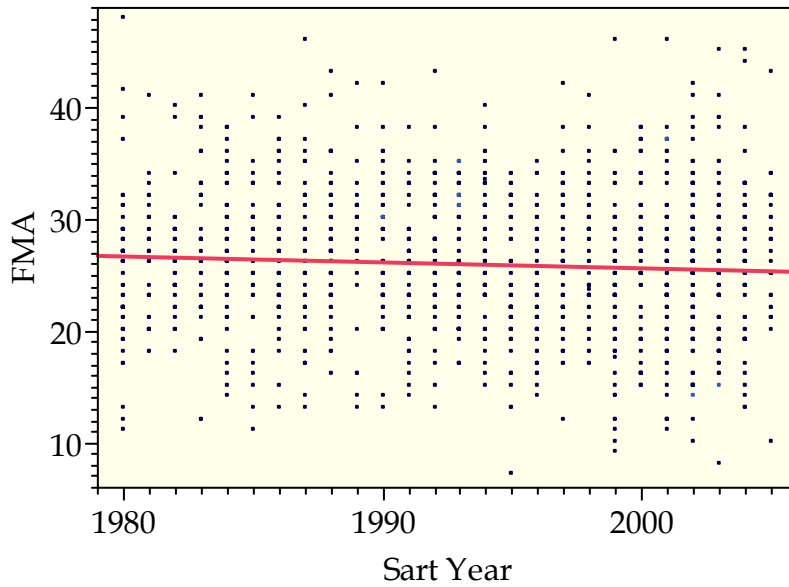


Figure 36. Plot generated by bivariate fit of FMA by start year for all cases. FMA significantly decreased from 1980 to 2005.

Table 23. Results of bivariate fit testing for a significant change in the FMA in all patients over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	125.0589	43.11605	2.90	0.0038
Start Year	-0.049701	0.021624	-2.30	0.0217

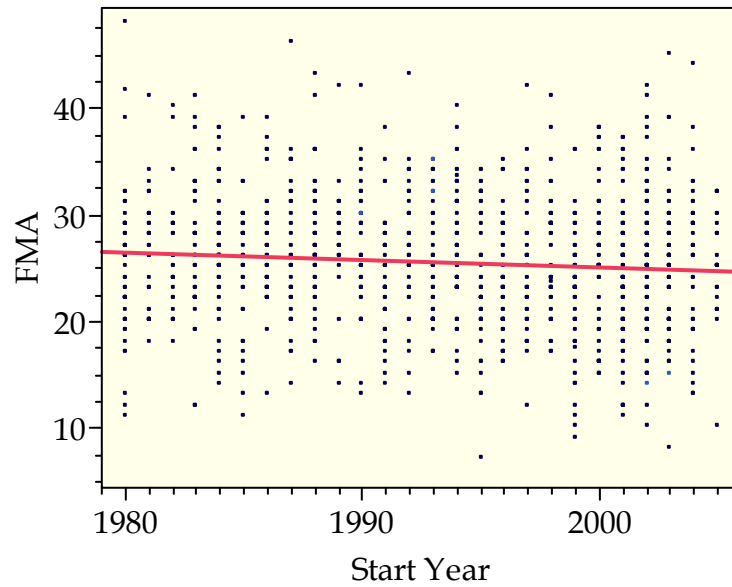


Figure 37. Plot generated by bivariate fit of FMA by start year for White patients only.

FMA significantly decreased from 1980 to 2005:  $FMA = 165.41 - 0.07(\text{Start Year})$ .

Table 24. Results of bivariate fit testing for a significant change in the FMA in White patients over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	165.41877	47.33555	3.49	0.0005
Start Year	-0.070177	0.023745	-2.96	0.0032

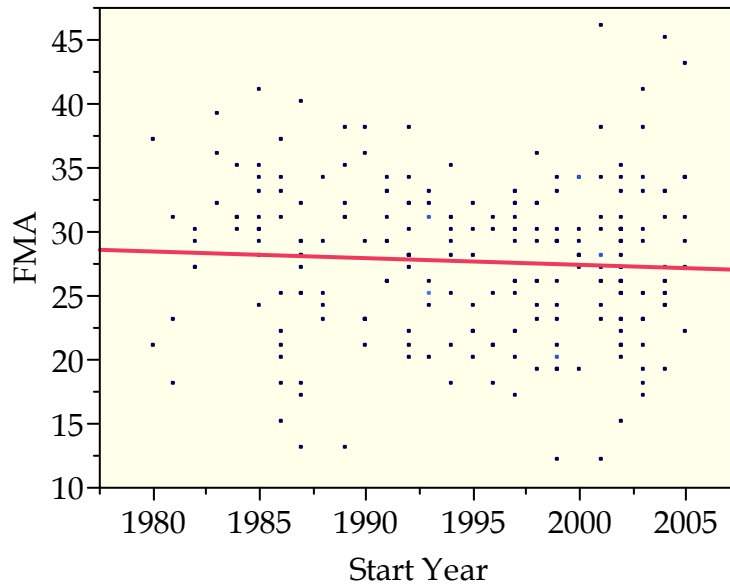


Figure 38. Plot generated by bivariate fit of FMA by start year for Black patients only.  
 FMA has not significantly changed from 1980 to 2005:  $FMA = 132.48 - 0.05(\text{Start Year})$ .

Table 25. Results of bivariate fit testing for a significant change in the FMA in Black patients over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	132.48264	110.2289	1.20	0.2306
Start Year	-0.052537	0.055246	-0.95	0.3426

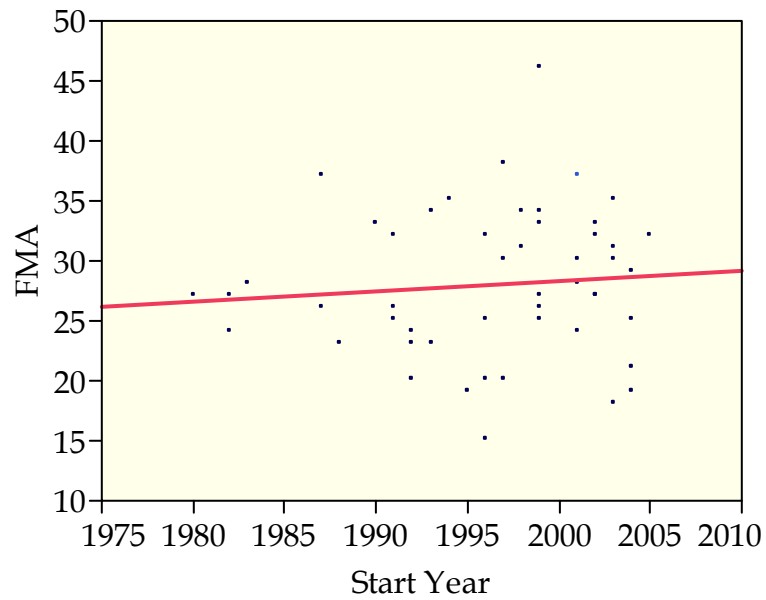


Figure 39. Plot generated by bivariate fit of FMA by start year for “other” patients only.  
 FMA has not significantly changed from 1980 to 2005:  $FMA = -138.38 + 0.08(\text{Start Year})$ .

Table 26. Results of bivariate fit testing for a significant change in the FMA in “other” patients over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	-138.3856	268.7797	-0.51	0.6090
Start Year	0.0833487	0.134641	0.62	0.5388

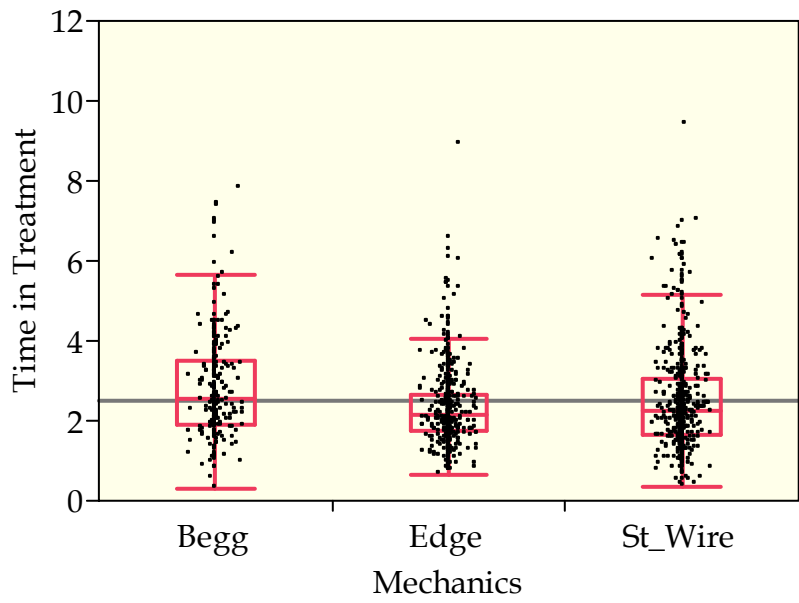


Figure 40. Plot of time in treatment by mechanics. Begg treatment averaged 2.8 years, standard edgewise treatment averaged 2.3 years, and straight-wire edgewise averaged 2.5 years. Average treatment times were significantly different.

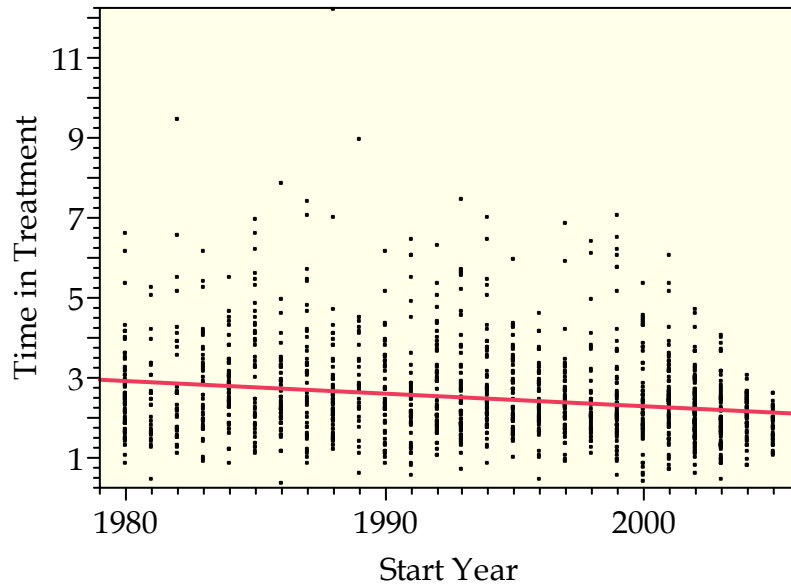


Figure 41. Plot generated by bivariate fit between the year of case start against time in treatment for all cases.

Time in treatment significantly decreased over the interval studied: Time in TX =  $67.15 - 0.03(\text{Start Year})$ . Interpretation of this best-fit equation is that time in treatment diminished by 0.03 years per year, which is about 3½ months per decade.

Table 27. Results of bivariate fit testing for a significant change in time in treatment over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	67.15206	8.376662	8.02	<0.0001
Start Year	-0.032436	0.004201	-7.72	<0.0001

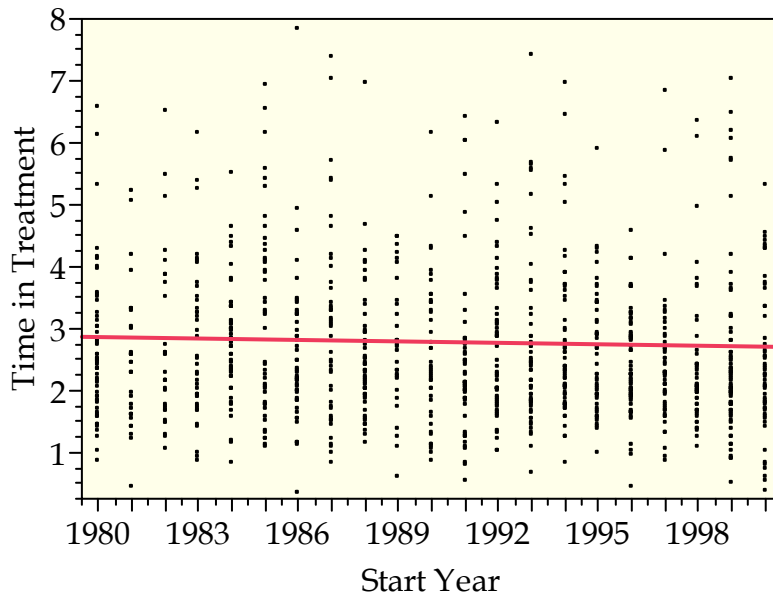


Figure 42. Plot generated by bivariate fit of time in treatment by start year for Begg cases only.

Time in treatment has not significantly decreased over the time studied for Begg mechanics:  $\text{Time in TX} = 18.58 - 0.01(\text{Start Year})$ . Interpretation of this best-fit equation is that treatment time diminished by about 0.01 years per year, which is about one month per decade.

Table 28. Results of bivariate fit testing for a significant change in time in treatment for Begg cases over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	18.582704	34.95218	0.53	0.5954
Start Year	-0.007935	0.017589	-0.45	0.6523

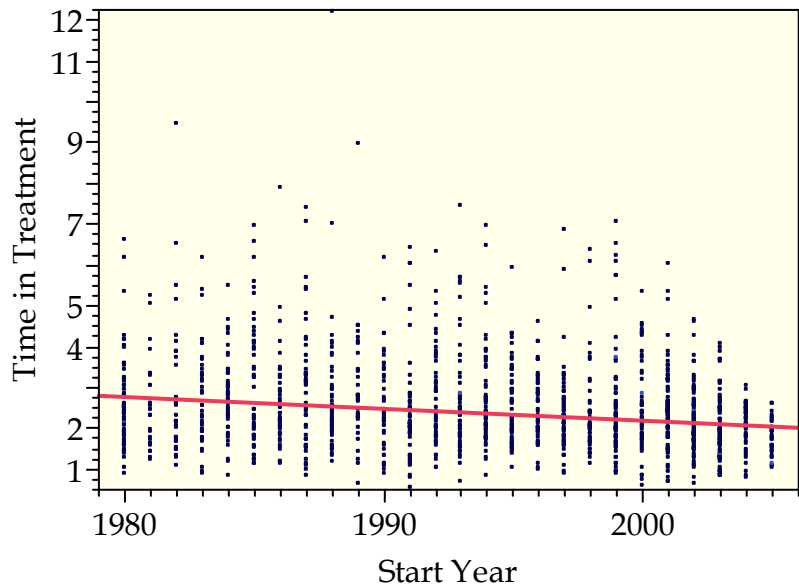


Figure 43. Plot generated by bivariate fit of time in treatment by start year for standard edgewise cases only. Time in treatment has significantly decreased over the time studied for standard edgewise mechanics:  $\text{Time in TX} = 59.66 - 0.03(\text{Start Year})$ . This decrease translates to about 0.03 years per year, which is about 3½ months per decade (3.6 months).

Table 29. Results of bivariate fit testing for a significant change in time in treatment for standard edgewise cases over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	59.658566	13.06305	4.57	<0.0001
Start Year	-0.028734	0.006546	-4.39	<0.0001



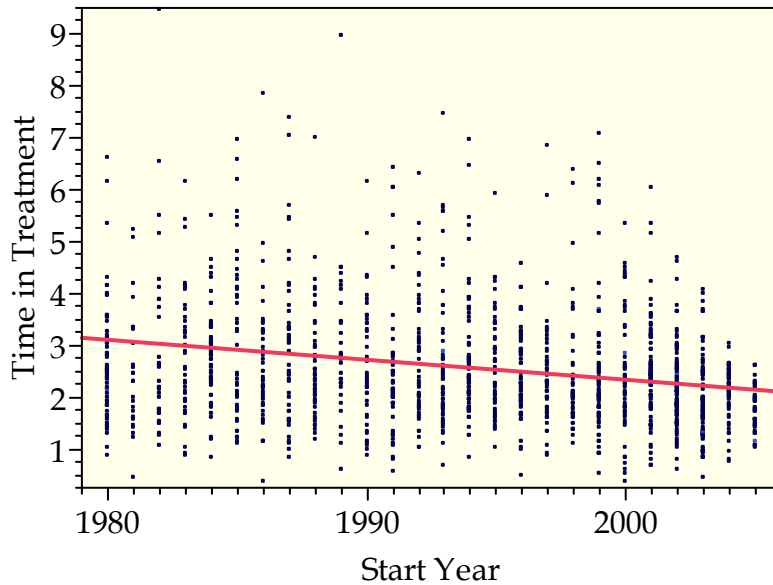


Figure 44. Plot generated by bivariate fit of time in treatment by start year for straight-wire cases only. Time in treatment significantly decreased over the time studied for straight-wire mechanics:  $\text{Time in TX} = 80.06 - 0.04(\text{Start Year})$ . This decrease is 0.04 years per year, which is about 4.7 months per decade. This is the largest of the changes observed.

Table 30. Results of bivariate fit testing for a significant change in time in treatment for straight-wire cases over the quarter century surveyed.

Term	Estimate	Std Error	t-test	P-value
Intercept	80.05632	13.95133	5.74	<0.0001
Start Year	-0.038869	0.006991	-5.56	<0.0001

## Treatment Duration and TennCare

On average, TennCare patients spent slightly more time (2.64 years) in treatment than non-TennCare patients (2.47 years), although this difference was not significant ( $F = 1.2$ ;  $P = 0.28$ ; **Figure 45**).

## Treatment Duration, Angle Class and Extraction

By two-way factorial ANOVA, both Angle classification ( $F = 19.9$ ;  $P < 0.0001$ ) and whether or not extractions were part of treatment ( $F = 37.5$ ;  $P < 0.0001$ ) had a significant effect on treatment duration. When Angle class and extraction category were crossed (*i.e.*, the interaction effect),  $F = 3.2$  and  $P = 0.0117$ . When controlling for extractions, the mean treatment time was 2.3 years for Class I patients, 2.6 years for Class II patients and 2.5 years for Class III patients. When controlling for Angle Class, the mean treatment time for non-extraction patients was 2.2 years and 2.7 years for extraction patients. Mean treatment times are graphed in **Figure 46**, and this shows the source of the significant interaction term. Begg treatment took longer on the average to treat Class I and Class II cases, but it seems to have been more efficient at treating Class II cases.

Archived cases from the Department of Orthodontics are coded to what extraction pattern (if any) was involved. For individual extraction patterns the mean time in treatment is as follows: Non-extraction, 2.25 years; 4 first premolars, 2.72 years; 4 second premolars, 2.52 years; maxillary first premolars and mandibular second premolars, 2.69 years; maxillary second premolars and mandibular first premolars, 2.59 years; and maxillary first premolars only, 2.69 years. A Tukey-Kramer HSD comparisons test showed that significant differences between treatment times existed between non-extraction and (1) four first premolar extraction ( $P < 0.0001$ ), (2) maxillary first and mandibular second premolar extraction ( $P = 0.009$ ), and (3) maxillary first premolar only extraction ( $P = 0.006$ ), with extraction cases taking longer to treat than non-extraction cases. However, for cases with (1) all second premolars extracted, and (2) maxillary second premolars and mandibular first premolars extracted, there was no statistical difference in treatment time when compared to non-extraction or with any other extraction pattern. No extraction pattern was found to be significantly different in treatment time to any other extraction pattern.

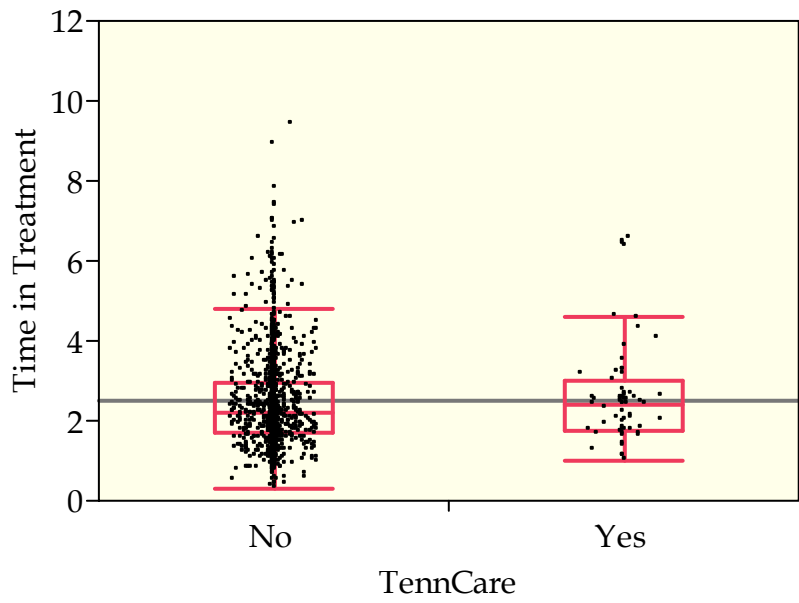


Figure 45. Plot of time in treatment by whether or not the patient had TennCare. TennCare patients did not significantly differ in time in treatment from non-TennCare patients.

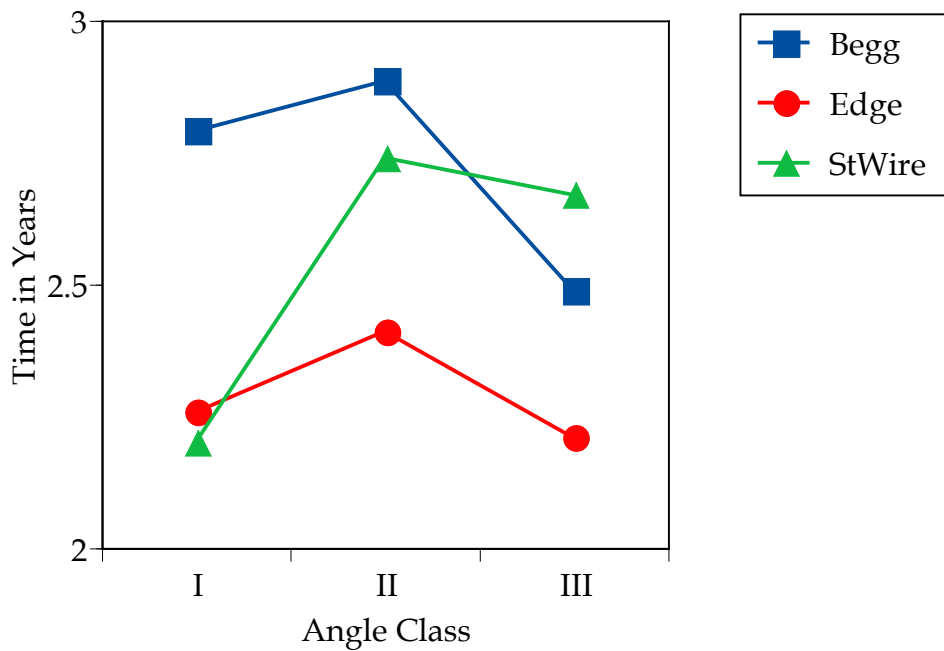


Figure 46. Mean treatment times for Begg, standard edgewise, and straight-wire edgewise mechanics by Angle class.

## Treatment Duration and the FMA and ANB Angle

The ANB angle and the FMA both showed small but significant effects on treatment time. As both the ANB angle ( $P = 0.0007$ ) and the FMA ( $P = 0.02$ ) increase, treatment time increases (**Figure 47, Table 31** and **Figure 48, Table 32**). This increase treatment time is very small, only evident due to the large data set for this survey, and it has little or no clinical relevance ( $r^2 = 0.009$  and  $r^2 = 0.004$ , respectively). One might suppose that increasing ANB angle would increase treatment difficulty (as reflected in treatment time), so there would be a U-shaped line fitting the data (with the shortest time coinciding with ANB = 0). In fact, cases with negative ANB angles evidently treated out rather quickly (**Figure 47**), whereas those with positive ANB angles (*i.e.*, mandibular retrognathic cases) took the longest to complete.

## Treatment Duration and Race

On average, Black patients took about 2 months longer to treat than White patients (**Figure 49**), although this difference was not significant ( $F = 2.85$ ;  $P = 0.09$ ).

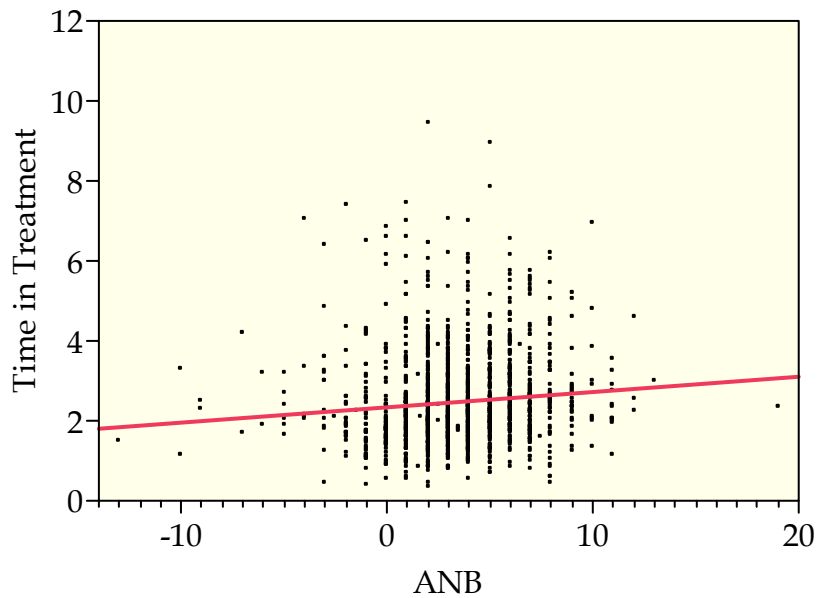


Figure 47. Plot generated by bivariate fit of time in treatment by ANB angle. As the ANB angle increases, time in treatment increases significantly:  $\text{Time in TX} = 2.35 + 0.038(\text{ANB})$ . This equation can be read that each degree of positively increasing ANB adds an average of about  $\frac{1}{2}$  month to treatment. While significant statistically, many other factors interfere with the precision of this trend.

Table 31. Results of bivariate fit testing for a significant change in time in treatment by ANB angle.

Term	Estimate	Std Error	t-test	P-value
Intercept	2.3498306	0.05148	45.65	<0.0001
Start Year	0.0378335	0.011194	3.38	0.0007

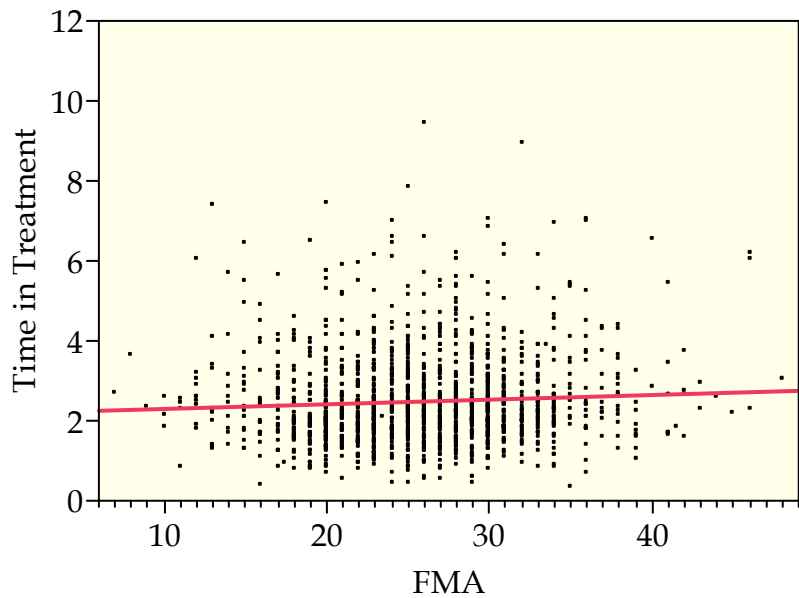


Figure 48. Plot generated by bivariate fit of time in treatment by the FMA. As the FMA increases, time in treatment increases significantly:  $\text{Time in TX} = 2.15 + 0.012(\text{FMA})$ .

Table 32. Results of bivariate fit testing for a significant change in time in treatment by the FMA.

Term	Estimate	Std Error	t-test	P-value
Intercept	2.1515567	0.139579	15.41	<0.0001
Start Year	0.0124539	0.005245	2.37	0.0177

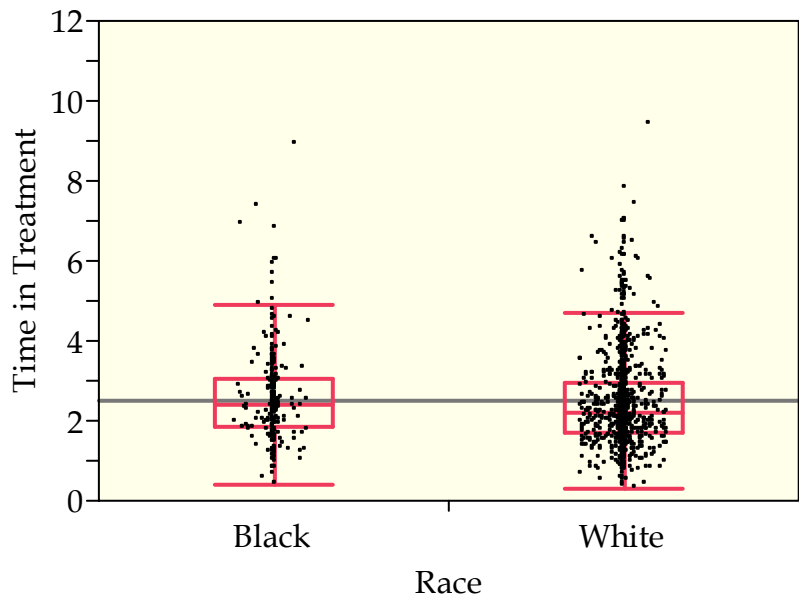


Figure 49. Plot of time in treatment by race. Treatment time averaged 2.61 years for Black patients and 2.46 years for White patients. This difference was not significant ( $P = 0.09$ ).

## CHAPTER V: DISCUSSION

### Ethnic Groups

Although differences in malocclusion do exist among different racial and ethnic groups, there is no difference in the overall need for orthodontic treatment among groups (Kelley and Harvey 1977; Proffit *et al.* 1998). That being said, the racial proportions of our patient sample should mirror the proportions of the population of Memphis, but this is not the case. As shown in **Table 33**, Whites are over-represented in our patient sample (75%) when compared to the population of Memphis (34%), while Blacks are under-represented in our patient sample (21%) compared to the population of Memphis (61%). Other races or ethnic groups may be slightly over or under represented, but not nearly to the extents of Blacks and Whites (**Table 33**).

This discrepancy is consistent with reported literature showing that Whites are more likely to obtain orthodontic treatment. Okunseri *et al.*, report that in a survey of over 14,000 households for the National Medical Expenditure Survey (MEPS 1996), of respondents claiming to have visited the orthodontist at least once in the past year, 85% were White, 4.5% were Black, 6.7% were Hispanic, 2.5% were Asian and the rest were “other” (2007). Data from the NHANES III reveal that in the 8 to 17 age group 22.9% of Whites, 6.1% of Blacks, and 8.3% of Mexican-Americans had received orthodontic treatment (Proffit *et al.* 1998). The reasons for this racial discrepancy seem to be multi-factorial and include socioeconomic, educational, and cultural variables, as well as a decreased demand for orthodontics among Black parents compared to White parents. (Wheeler *et al.* 1994; Okunseri *et al.* 2007).

Table 33. Proportions of the total sample by race compared with the respective proportions in the population of the city of Memphis.

Race	Count	Percent	Memphis
Asian	29	1.799	1.5
Black	342	21.216	61.4
Hispanic	7	0.434	3.0
Indian	11	0.682	0.3
Islander	1	0.062	0.0
Mideast	5	0.310	—
White	1217	75.496	34.4

Source: U.S. Census 2000.



While a racial/ethnic disparity in orthodontic treatment does exist, in our sample this disparity was found to be decreasing over the time interval. From 1980 to 2005 there was a significant increase of both Black and “other” patients compared to White patients. This increase is promising and may reflect a greater demand for treatment, an increase in access to treatment, and an increase in awareness concerning orthodontic treatment among Blacks and minorities. The increase in treatment of non-White patients seen in the present sample was also found by Manski *et al.* who report that from 1987 to 1996 the percentage of non-White patients visiting an orthodontist increased significantly from 1.5% to 2.1% (2000).

TennCare, Tennessee’s Medicaid program, may have something to do with greater access to care among the urban poor in Memphis. The population demographic of the city of Memphis where the University clinic is located is predominantly an inner-city Black population. In 1999, a faculty member in the department of orthodontics became a TennCare provider and since then there has been a significant increase in TennCare patients seen at the Department of Orthodontics. This increased access to care at the University Clinic may contribute to the increase in non-White patients. While only 5% of all patients in the sample were subsidized by TennCare, 22% of Black patients were.

### Sex Distribution

National surveys of the occlusal needs of youths in the United States show that the frequencies and severities of malocclusion are the same in boys and girls, especially after accounting for the greater uptake of orthodontic services by females (Kelly and Harvey 1977; Brunelle *et al.* 1996; Proffit *et al.* 1998). And yet, evidently because of greater esthetic concerns by girls and their parents, orthodontic practices consist of a preponderance of girls. Of note, actual data confirming this sex difference in the actual uptake of orthodontic services are rare. Although the literature agrees that girls do not have a greater need for orthodontics (Tang and So 1994; Wheeler *et al.* 1994; Birkeland *et al.* 1996; Kelley and Harvey 1997; Al Yami *et al.* 1998; Leipa *et al.* 2003; and Souames *et al.* 2006), significantly more girls than boys receive orthodontic treatment (Kelly and Harvey 1977; Wheeler, *et al.* 1994; Brunelle, *et al.* 1996; Al Yami *et al.* 1998).

Our results agree with the literature and reveal that 59% of the sample (n = 6,927) is female, a highly significant difference from an expected 50:50 ratio of males to females. This 6-to-4 female-to-male ratio of orthodontic patients has also been found by other researchers. In a survey of 1,000 consecutively treated patients in Britain, and almost 1,500 patients in Belgium, this same ratio was reported (Rose 1974; Willems *et al.* 2001). This ratio also appears in a British

study of patients referred for orthodontic treatment in a socialized medical system. Of those referred, 62% of the patients accepted for orthodontic treatment were female and only 38% were male (O'Brien *et al.* 1996). Likewise, a random assessment of 920 orthodontic patients in the Netherlands revealed that 56% of those patients treated were female. It appears that this 6 to 4 ratio of female to male patients, or a ratio close to it, may be rather universal in westernized countries.

Of note, this ratio did not change over the studied time interval. We found no literature that has specifically investigated the sex ratio of orthodontic patients through time, however, data from the NHANES III suggests that the disparity between boys and girls being treated orthodontically may have decreased. That study divided patients into adult and child/adolescent groups. While a greater percentage of both adult and child/adolescent girls had received orthodontic treatment when compared to boys, more boys and fewer girls in the younger age group are receiving treatment when compared to the older age group (Brunelle *et al.* 1996).

Sex role stereotyping, where parents and society place a greater emphasis on female physical beauty, is well documented in the literature (Pahl-Andersen 1978; Shaw 1991). This, combined with the fact that girls are more critical of their dental appearance and express a higher desire for orthodontic treatment (Shaw 1981; Liepa *et al.* 2003; O'Brien *et al.* 2006) explain why more girls than boys receive orthodontic treatment although there are no sex differences in malocclusion or treatment need.

### Angle Classification

In the present sample Angle Class II cases was the most common molar relationship encountered (50%), followed by Class I cases at 41% and Class III cases at about 9%. This is substantially different from proportions found in the general population where 53% of children are Class I, 32% are Class II, and 14% are Class III (Kelly and Harvey 1977). When evaluating the sample, it is important to remember that these are cases that were treated at the University Clinic and therefore are more likely than untreated or mixed treated/untreated samples to contain malocclusions, specifically Class II and Class III cases.

Reports on Angle Classification are widely varied (**Table 34**), but our results are somewhat similar to results found by Willems on 1,500 Belgian orthodontic patients (2001). Willems' data also revealed a preponderance of Class II cases, likely for the same reason our data did: people who have more severe malocclusion are more likely to become orthodontic patients. The only

Table 34. Proportions of Angle Class from various studies.<sup>1</sup>

Study	Class I	Class II	Class III	Race/Sample
Angle (1907)	69.2	21.6	4.2	White,ortho
Massler (1951)	50.0	19.4	9.0	White,mixed
Altemus (1957)	66.4	12.0	5.0	Black,mixed
Emrich (1965)	85	14	1	Mixed,mixed
Kelly, Mixed (1977)	53	32	14	Mixed,mixed
Kelly, Black (1977)	62	18.0	18.6	Black,mixed
Kelly, White (1977)	52	33.6	13.0	White,mixed
Willems (2001)	31	62	6	Mixed,ortho
Current Study, Mixed	41	50	9	Mixed,ortho
Current Study, Black	51	31	17	Black,ortho
Current Study, White	42	51	7	White,ortho

<sup>1</sup> Coding defines: 1) whether a study is based on a Black, White, or unspecified mixed race sample, and 2) whether the sample consisted of orthodontic patients only, or a mixed treated and untreated sample.

other non-mixed sample found was in a report by E.H. Angle in 1907 where the majority of his patients (69%) were Class I.

The Black-White difference in Angle Classification reported in the literature (Kelley and Harvey 1977) is mirrored in the current sample. Blacks are more likely to have a Class I (51% vs 42%) or Class III (17% vs 7%) malocclusion than Whites, while Whites are more likely to have a Class II malocclusion than Blacks (51% vs 31%). Altemus (1957) reported on a Black sample and found a much lower percentage of Class III Black patients (5%) than in the current study (17%), however, his sample was a mixed sample of treated and untreated children compared to our sample consisting of those actually being treated because of a malocclusion. Still, the percentage of Black Class III patients from the Altemus study is low compared to the mixed treated/untreated sample of Kelly and Harvey (1977).

Interestingly, over the 26 years surveyed, the ratio of Angle Classes has changed significantly. Comparatively more Class I patients are being treated compared to Class II patients and more Class III patients are being treated compared to Class II patients. Although the reasons for these changes are not clear, some hypotheses can be formed. It may be that as the University struggles to maintain a high volume of “good teaching cases” for its graduate students, the standard of difficulty for a patient to be accepted into the program has declined. If true, this may explain the increase of Class I cases compared to Class II cases, as “easier” patients are accepted for treatment. The increase of Class III cases

compared to Class II cases could at least partially be explained by the fact that relatively more Black patients (with a higher incidence of Class III malocclusion) compared to White patients (with a higher incidence of Class II malocclusion) are being seen in the University Clinic over the surveyed time.

### Orthognathic Surgery

According to Dr. Jimmy Albright, a long time faculty member of the Department of Oral Surgery at the University, the reason for the decline in orthognathic surgery case is due to the fact that the faculty of the Department of Orthodontics refers fewer patients for orthognathic procedures than they did in the past. Albright and his team perform the same number of orthognathic procedures that they always have, just with fewer of the referrals coming from the orthodontic department (Albright, pers. comm.). There are several possible reasons that the Department of Orthodontics refers fewer patients for surgical procedures. These include an increase in the use of functional appliances, such as the Herbst, the MARA, and the bionator, and an increase in early treatment in the department.

### Treatment Mechanics

Orthodontic treatment mechanics at the University over the time surveyed can be grouped into three types: Begg mechanics, standard edgewise mechanics (Tweed), and straight-wire edgewise mechanics. Students are assigned specific numbers of patients to certain instructors who treat in one of the above categories. Consequently, trying to compare treatment mechanics at the University to anything going on in private practice would be somewhat artificial. In 1999, the University discontinued Begg mechanics as a treatment modality. This reflected a national trend away from Begg treatment, which was once very popular, especially in the U.S. South. As Begg mechanics, once the predominant method taught at the school, was discontinued, standard edgewise and straight-wire edgewise cases both increased to roughly 50% of treated cases and this 1:1 ratio has not changed significantly in the quarter-century surveyed. As stated, this ratio is artificial and does not compare to anything happening at any geographical level because each student is assigned specific cases to specific teachers by the clinic director or department chair. In fact, the majority of practitioners in the United States do not use a standard-edgewise appliance, but rather a straight-wire edgewise appliance.

## Extraction Frequency

The frequency of extractions as a part of orthodontic treatment was found to decline over the quarter-century surveyed in this study. Overall, extraction cases made up over 70% of all cases in 1980. This percentage is much higher than reported by Peck and Peck (42% in 1979), Ricketts (33% in 1976), and Weintraub (39% average in 1986), but lower than Tweed who reported extractions in 80% of patients in 1966 (Peck and Peck 1979). The incidence of extractions as part of treatment steadily declined over the time interval to roughly 40% of all cases in 2005. Furthermore, this decline in extraction treatment is evident within each of the three types of treatment mechanics taught at the university, namely Begg, standard edgewise, and straight-wire edgewise. Of note, extraction in standard edgewise treatment fell from roughly 85%, a little bit higher than what was reported by Charles Tweed (1966), to about 50% of cases, the percentage of which Tweed (1945) once thought that four premolar extractions were necessary.

The decrease in orthodontic extractions over time is evident from the literature. Brian and O'Connor (1993) found a 22% decline in extractions from 1984 to 1989 with more than 50% of orthodontists surveyed reporting a decrease in extraction frequency. This number may, however, be inaccurate. Weintraub reported in 1989 that orthodontists' self-estimations of extraction percentages were often inaccurate, with reported extraction rates ranging from a 20% overestimation, to a 15% underestimation. Proffit (1994), in a study similar to the present one, conducted at the University of North Carolina, found a fluctuating extraction frequency that went from 30% in 1953, to 76% by 1968, and slowly back down to 28% in 1993, which is considerably lower than the extraction rate at the University of Tennessee in 1993 (over 55%).

Reasons for the decrease in extraction frequency probably are varied. A desire for improved facial esthetics, TMJ concerns, medico-legal concerns, increased use of functional appliances and palatal expansion, and the use of bonded brackets rather than bands, have all been attributed to decreased extraction frequency (Weintraub 1989; Brian and O'Connor 1993; Proffit 1994).

## Treatment Duration

Treatment Duration at the University of Tennessee averaged 30 months. This is on the higher end of the spectrum reported in the literature, which ranged from 22 to 31 months (Vig *et al.* 1990; Fink and Smith 1992; Alger 1998). Factors such as the student learning curve, student breaks, patient transfers, and limited appointment availability of faculty members, no doubt, increase treatment time in this university setting compared to a private practice setting.

Factors found to have a significant influence on treatment time include type of mechanics, Angle Classification, whether or not extractions were performed, FMA, and ANB angle. On average, Begg cases (34 months) took longer to treat than straight-wire edgewise cases (30 months), which took longer to treat than standard edgewise cases (28 months). Reasons for this are not entirely clear, but can be hypothesized. Begg mechanics may take longer than the other mechanics, because of a steep learning curve, while straight-wire edgewise mechanics may take longer than standard edgewise mechanics because practitioners are more likely to employ phased treatment or use functional appliances or palatal expanders .

Extraction of (1) four first premolars (2.72 years), (2) maxillary first premolars and mandibular second premolars (2.69 years), and (3) maxillary first premolars only (2.69 years) were all found to significantly increase treatment time compared to non-extraction treatment (2.25 years). However, cases with the extraction patterns of (1) all second premolars and (2) maxillary second premolars and mandibular first premolars, there was no significant difference in treatment time when compared to non-extraction. No individual extraction pattern was found to be significantly different from any other extraction pattern in regards to treatment time.

Depending on the extraction pattern, the significant increase in treatment time for extraction treatment ranges from 3.2 months to 5.6 months. These increases are comparable to Fink and Smith (1992) and Alger (1998) who report that extraction increases treatment time by 3.6 months and 4.6 months, respectively.

Angle classification also had a significant effect on treatment duration. After controlling for extractions, the mean treatment time was 2.3 years for Class I patients, 2.6 years for Class II patients, and 2.5 years for Class III patients.

The cephalometric variables investigated in this study, the FMA and ANB angle, both were found to have a significant effect on treatment duration, with larger angles correlating with an increase in treatment time. Each degree increase in the ANB was associated with an increase in treatment time of almost half a month. This is consistent with the findings of Fink and Smith who found an increase in treatment time with an increasing ANB (1992). The effect of FMA on treatment time is significant, but not clinically relevant and is only evident due to the large sample in this study. Our findings, that treatment time only increased 5 days a year per degree increase in FMA, are at odds with Fink and Smith who report a 0.3 months per degree decrease in treatment time (1992).

Throughout the quarter-century surveyed in this study, there is a decrease in the overall treatment time for standard edgewise and straight-wire edgewise cases, but no change in the Begg cases. Treatment time decreased 3.6 months per decade for standard edgewise cases, and 4.7 months per decade in straight-wire cases. Reasons for this decrease are unclear but can be hypothesized. In 1998 the orthodontic program went from a 2 year to a 3 year program, most likely decreasing treatment time by decreasing patient transfers among students. A new chairman who started in 1999 also began to implement new policies and hire more full time faculty which may have led to a decrease in treatment time. It is also probable that the patients being treated more recently have less severe malocclusions than those treated more towards the beginning of the surveyed interval. As the clinic struggles to maintain enough “good teaching cases” for each student, less severe cases are admitted as become patients. This idea is supported by findings in the current study that more Class I cases are being treated compared to Class II cases as time moves forward over the surveyed period (**Figure 7**).

## CHAPTER VI: SUMMARY AND CONCLUSIONS

The present study provides a unique look into orthodontic treatment at a graduate orthodontic clinic. Patient demographics, dental and skeletal relationships, and treatment variables, as well as temporal trends, reveal who is actually seeking orthodontic treatment, receiving that treatment, what type of treatment was received, and how all of these variables have changed over time. This information not only adds to the orthodontic literature, but provides a valuable “audit” of orthodontic treatment at The University of Tennessee Graduate Orthodontic Clinic from 1980 to 2005. Major findings of this research are:

1. Black patients are grossly under-represented in the patient population, but the frequency of Black patients and “other” non-White patients have significantly increased compared to White patients over the quarter-century surveyed.
2. The ratio of girls to boys treated orthodontically is 6:4. This ratio has not changed over the surveyed time interval and reflects the greater esthetic concern for girls compared to boys that is well documented in the literature.
3. Fifty percent of the cases surveyed exhibit an Angle Class II molar relationship, 41% exhibit Class I relationship, and 9% exhibit a Class III relationship. Over time, this ratio has changed as comparatively more Class I patients are being treated compared to Class II patients, suggesting either that more patients with less severe malocclusions are seeking treatment or that the clinic is accepting less severe malocclusions for treatment.
4. A Class III molar relationship is more common in Black patients (17%) than White patients (7%), while a Class II relationship is more common in Whites (51%) than Blacks (31%). This difference is well documented in the national epidemiological studies of occlusion.
5. Two percent of patients treated at the graduate clinic received treatment that involved orthognathic surgery. Over time the frequency of surgical procedures has decreased. This decrease is thought to occur because orthodontic treatment planning at the clinic is less likely to involve orthognathic surgery, perhaps because this treatment is expensive and it is increasingly difficult to receive insurance approval for such procedures.
6. Over the surveyed time interval, there was a significant increase in the age of patients, reflecting a greater desire for adult orthodontic treatment as time went forward.
7. Treatment with Begg mechanics, once the most common technique at the University, ceased in 1999. Discounting Begg mechanics, slightly more



patients were treated with a straight-wire edgewise appliance (53%) than a standard edgewise appliance (47%), and this ratio did not change over time.

8. Extraction cases of all types decreased over time from above 70% down to below 50% of all cases. Treatment with Begg, straight-wire, and standard edgewise mechanics all showed a decrease in extraction frequency over time. The reason for this decrease is multifactorial, but involves an increased concern for patient esthetics, TMD concerns, and the use of functional appliances and palatal expansion.
9. Over the surveyed time 52% of Class I patients, 60% of Class II patients, and 46% of Class III patients were treated with extraction.
10. Approximately 5% of all cases and 9% of cases treated from 2000 to 2005 were subsidized for treatment by TennCare. The number of these cases increased over the surveyed time interval.
11. Non-extraction treatment was only found to be of shorter duration when compared to three extraction patterns (4-4/4-4, 4-4/5-5, and 4-4/0-0); no other extraction pattern involving premolars was found to be of longer duration than non-extraction, and treatment duration difference between all extraction patterns were not significant. After controlling for Angle Class, non extraction treatment averaged 2.2 years, while extraction treatment averaged 2.7 years.
12. The average duration of treatment is 2.5 years for all cases, 2.8 years for Begg cases, 2.3 years for standard edgewise cases, and 2.5 years for straight-wire edgewise cases. Treatment duration decreased over time possibly due to many factors, but most likely because of an increase in the number of patients with less severe malocclusions.
13. After excluding the effects of extraction on treatment time, the mean treatment time was 2.3 years for Class I patients, 2.6 years for Class II patients, and 2.5 years for Class III patients.
14. Treatment time increased as the ANB angle increased and the FMA increased. Although the treatment time increase is significant, it is so small that it is clinically imperceptible.

The present study, because of its size and scope, encountered certain limitations. Future studies, more likely on a smaller scale, could look more closely at factors affecting treatment time. The number of broken appointments and phased treatment were not examined in this study and both have a significant effect on treatment duration. The number of patient visits, rather than calendar time may be a better indicator of treatment duration. This study also fails to account for how the outcome of orthodontic treatment affects treatment duration and any future studies may want to account for this factor.

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## VITA

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