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OUTCOME ASSESSMENT OF ORTHODONTIC TREATMENT PROVIDED BY ORTHODONTIC SPECIALISTS AND NON-ORTHODONTISTS

by

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Abstract

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This study compared orthodontic treatment outcome between patients treated by orthodontic specialists and patients treated by dentists without specialty training in orthodontics (non-orthodontists) using four different indices. The sample consisted of 196 dental casts collected in 1997 and 1998 from 1047 orthodontically treated tenth grade students attending high school in Cuyahoga County. All casts were scored using the Peer Assessment Rating Index (PAR), the Deflection Index (DI) and the American Board of Orthodontics Objective Grading System (ABOI). A subset of 50 dental casts treated by orthodontic specialists and 50 dental casts treated by non-orthodontists, were randomly selected and used for Q-sorting. For the Q-sorts 9 experienced orthodontists sorted these 100 casts into three groups: Good, Acceptable, and Poor. All testing was done with the examiners blinded to the provider's level of education. The mean post treatment PAR scores for the patients treated by orthodontic specialists and non-orthodontists were 11.7 ± 5.5 and 10.9 ± 5.25, respectively. The scores for the Deflection Index were 11.2 ± 7.5 for orthodontic specialists versus 13.0 ± 5.9 for non-orthodontists. The mean ABO Objective

Grading System scores were, 26.0 ± 11.4 for orthodontic specialists, versus 29.6 ± 12.8 for non-orthodontists. The Q-sort scores for orthodontists and non-orthodontists were 16.6 ± 4.75 versus 15.4 ± 5.37, respectively. There was no significant difference between mean scores for the PAR Index, the Deflection Index, or the Q-sort scores. However the difference in mean ABO Objective Grading System scores were statistically significant ($P \leq 0.04$). Of the seven components used in the ABO Objective Grading System, the alignment of teeth was found to be most significant (0.0007). Thus, we conclude that the ABO index was the only outcome measure that detected a difference between casts treated by orthodontists and non-orthodontists.

DEDICATION

To God, who makes everything possible.

To my parents, Drs. Toshihiko and Yoko Abei who have helped me to achieve all of my goals. I could never have done it without all of your support.

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Page

5. The PAR Database for Orthodontic Specialists.....85

6. The Deflection Index Scoring Sheet.....87

7. The Deflection Index Database for Non-orthodontists.....88

8. The Deflection Index Database for Orthodontic Specialists.....89

9. The ABO Objective Grading System Ruler.....91

10. The ABO Objective Grading System Scoring Sheet.....92

11. The ABO Objective Grading System Instruction.....93

12. The ABO Database for Non-orthodontists.....115

13. The ABO Database for Orthodontic specialists.....116

14. The Q-sorts Scoring Sheet 118

15. The Q-sorts Database for Non-orthodontists.....119

16. The Q-sorts Database for Orthodontists.....120

17. The Q-sorts Individual Database 121

18. Comparison 100 Dental Casts and 196 Dental Casts.....123

19. Comparison of Indices.....124

20. Publication Version 1.....125

21. Publication Version 2.....141

LITERATURE CITED.....153

LIST OF FIGURES

Figure Page

1. Sample selection.....55

LIST OF TABLES

Figure Page

1. Development of Indices.....42

2. The Deflection Index Measurements.....53

3. Post Treatment PAR Score (weighted).....63

4. The PAR Score (weighted) Compared by the Provider. 64

5. The Deflection Index Score for the Total Sample.....64

6. The Deflection Index by Score Provider.....65

7. The ABO Objective Grading System.....66

8. The ABO Objective Grading System Score by Provider Type.....66

9. The ABO Objective Grading System Score by Provider.....67

10. Q-sorts Chi Square Results.....67

11. Q-sorts t-test.....68

12. Person Correlation Coefficients for The PAR Index, The Deflection Index, ABO Objective Grading System and Q-sorts.....68

13. Intra Class Correlation Coefficient.....69

INTRODUCTION

Evidence based health care has become a hot button for the new century. As such, quantitative measures of treatment outcome have been increasingly more important, not only for health care providers, but also for health care consumers. Dental consumers are interested in value, i.e., obtaining the best quality service at the lowest cost. In a fee for service profession, such as orthodontics, cost comparisons are fairly straightforward. However, comparing quality is more difficult. There are many factors that contribute to successful orthodontic outcomes, including function, esthetics, stability, and alignment of teeth. Malocclusion, the poor alignment of teeth and jaws, is not a disease. Rather it is a collection of morphologic conditions with an indefinite cut off value between normal and abnormal. Some of the goals of orthodontic treatment are difficult to quantify, i.e., a healthy smile or a balanced profile. Facial esthetics, often considered an integral component of orthodontic treatment, is subjective and "in the eye of the beholder."

Despite some changes in the esthetic and functional goals of orthodontic therapy over time, one goal of treatment has always been "straight teeth". Fortunately, several valid and reliable indices have been developed to measure this outcome variable. The present study used four occlusal indices to compare the alignment and fit of the teeth between two groups of orthodontic treatment providers.

One group of providers had received specialty training in orthodontics and the other group had received no university training in orthodontics.

In 1999, Hans et al. reported that 11% of orthodontic treatment in Cuyahoga county was performed by non-orthodontists. They used the Peer Assessment Rating Index (PAR score) to quantify dental alignment. Surprisingly, they found that the average post treatment PAR score for a sample of 158 cases treated by orthodontic specialists was 11.2 ± 5.4; whereas, the average post treatment PAR score of a sample of 78 cases treated by non-orthodontists was actually lower (10.5 ± 4.9). Fortunately, at least for the orthodontic specialists, this difference was not statistically significant.

Hans et al. suggested two possible reasons for these findings. First, the PAR index was designed to measure improvement in alignment and uses both pre-treatment and post-treatment casts. In the Hans et al. study, only post-treatment casts were available. Therefore, one potential source of error in the study was that non-orthodontists were treating easier cases than orthodontists. To answer the first question, one hundred consecutive pre-treatment study casts from each of ten non-orthodontists and ten orthodontic specialists in Cuyahoga County, Ohio were examined. (Nguyen 2000) Nguyen reported that both provider groups treated slightly more females (non- orthodontic specialists 59%, versus orthodontic specialists 55%) with similar mean ages (non-specialists 15.4 ± 8.6, orthodontic specialist 14.7 ± 8.6) and similar mean pretreatment PAR scores (non- orthodontic specialist 21.6 ± 9.3 orthodontic specialists 22.2 ± 9.3). Nguyen concluded that there was no statistical

significant difference between pretreatment mean PAR scores for the two provider groups studied.

The second possible reason for a lack of a difference in the Hans et al. study was that the PAR Index was not sensitive enough to detect the difference. The present study was designed to address this question. In addition to the PAR Index, three other indices for scoring the straightness of teeth were selected. They were the Deflection Index (DI), the ABO Objective Grading system (ABOI), and the Q-sort (QI). Each index was used to evaluate the outcome of 126 cases treated by orthodontists and seventy cases treated by non-orthodontists. Although it may be argued that quality in orthodontics is more than just straight teeth, any practitioner wishing to provide orthodontic services for the public must, at the very least, be able to align the teeth.

LITERATURE REVIEW

Specialty of Orthodontics

The concept of moving teeth was recognized by ancient civilizations. One of the earliest written references to "crooked teeth" was by Hippocrates (460-377 B.C.). Centuries later, in 25 B.C, Celsius noted that teeth could be moved by finger pressure. But it was not until 1836 when a French dentist named LeFoulon, first used the term "orthodontia". The name of the specialty "orthodontics" comes from two Greek words: "orthos" (which means right or correct) and "dons" (which means tooth). However, another Frenchman, Pierre Fauchard, often called the "Father of Modern Dentistry", is generally given credit for the first comprehensive discussion of "regulating teeth". Moreover, he also designed a "bandelette," which is now called an expansion arch. In 1887, Edward H. Angle (1855-1930) presented his first scientific paper on the science of moving teeth. Angle's work that had a profound influence on the growth of what was to become dentistry's first recognized specialty. In 1905, Angle established the Angle School of Orthodontia in St. Louis. In addition to academia and private practice, Angle organized and served as the first president of the Society of Orthodontics. This Society would later evolve into the American Association of Orthodontics (AAO). Although Angle died in 1930, his influence in

the profession is still strong. The entire orthodontic world uses his classification system for types of malocclusion. His efforts to improve his specialty also included an unsuccessful push to make orthodontics a separate branch of medicine. However, Angle was among the first to support the concept that additional training, beyond that received in dental school, was necessary to allow dentists to successfully practice orthodontics.

Orthodontic Treatment Provided by Non-orthodontists

Surveys of dental practices seem to indicate wide variation and conflicting findings as to the amount of orthodontic treatment rendered by general practitioners. The surveys show 25 to 75 % of general practitioners render some kind of orthodontic treatment. For example, in 1980, Manasess and Dooley surveyed a random sample of 330 general dentists in the Chicago metropolitan area to determine the extent of orthodontic referrals and treatment performed by general dentists. Among 202 valid responses, approximately one-third of the respondents provided orthodontic treatment limited to minor tooth movement using mainly removable appliances whereas two-thirds provided no orthodontic treatment.

In 1985, Tayer and Kerr surveyed One hundred general dentists in Glasgow, Scotland and found that 45% provided some orthodontic treatment. According to the authors, this figure remained relatively constant since 1969. In a Canadian survey, Konchak and McDermott (1988) reported that between 20.1% and 34.2% of fully banded orthodontic patients in Canada were treated by general practitioners.

In 1989, McGann surveyed over 10,000 general dentists in the United States. The results indicated that 75 % of the respondents provided some type of orthodontic services in their practice and that those who provided such services were busier and better compensated than their colleagues.

In 1991, Jacob also surveyed the dentists who worked in general practices in Iowa. Of 1,159 questionnaires mailed, 728 (62.8%) were returned. Two hundred and forty-seven (33.9%) of the respondents indicated that they provided no orthodontic treatment; whereas, 481 (66.1%) (i.e., approximately two-thirds of the sample population) indicated that they provided orthodontic treatment. Out of the latter group, 333 respondents (45.7% of the sample population) said that they provided orthodontic care to fewer than ten of their patients. Jacobs generated descriptive measures of the profiles of providers of a high and low volume of orthodontic services in general practice.

Profile of Providers of a High Volume of Orthodontic Treatment

1. They refer significantly fewer patients to orthodontic specialists.

2. They perform a significantly larger percentage of major orthodontic treatment, and they use a significantly larger percentage of fixed appliances, functional appliances, and headgears.

3. The volume of limited orthodontic treatment rendered by them and the volume of removable appliances they use are not significantly different.

4. They convey a significantly greater desire to further increase the volume of orthodontic treatment.

5. Their predoctoral educational background, as reflected by their attendance at an in state versus an out-of-state dental school, was not significantly different.

6. They take significantly more hours of continuing education in orthodontics.

7. The distance from their offices to the nearest orthodontic office is not significantly different.

8. They are likely to have been in dental practice less than 20 years.

Profile of Providers of a High Volume of Patient Referrals to Orthodontic Specialists

1. The number of the providers of some orthodontic treatment in this group is not significant.

2. They perform a significantly lower percentage of major orthodontic treatment, and they use a significantly lower %age of fixed appliances, functional appliances, and headgears.

3. The volume of limited orthodontic treatment they render and the numbers of removable appliances they use are not significantly different.

4. They do not convey a greater desire to increase the volume of orthodontic treatment rendered.

5. Their predoctoral educational background, as reflected by their attendance at an in state versus an out-of-state dental school, is not significantly different.

6. The number of hours of continuing education they take is not significantly different. It should be noted, however, that Chi-square analysis in which hours of continuing education taken is treated as an independent variable indicates that practitioners who take five hours or more of orthodontic CE annually refer significantly fewer patients to specialists.

7. The distance from their offices to the nearest orthodontic office is not significantly different.

8. They are likely to have been in dental practice less than twenty years.

The Jacob study was designed to ascertain whether general practitioners who provide some orthodontic treatment to a relatively large proportion of their patients tend to limit themselves to the treatment of simple cases while they continue to refer more difficult cases or whether a high volume of orthodontic treatment is linked to an expanded scope of treatment and fewer referrals. Only four and seven tenth percent of the respondents signified that they did not refer patients to orthodontists. The majority of respondents (51%) refered one to four patients monthly, 34.2% referred five to ten patients monthly; whereas, 8.5% of the respondents refer more than ten patients monthly. The results obtained were used to generate descriptive measures of the profiles of providers of a high volume of orthodontic services in general practice.

In 1995, Lawrence looked at the amount and variety of orthodontic services provided by general dental practitioners in Melbourne and Victoria, Australia. A random sample of 307 dentists drawn from the Victorian Dentists Register was surveyed by a mailed questionnaire, and 218 (71%) replied. At the time of the survey, 59% of the dentists saw at least one orthodontic patient and one dentist saw sixty-six orthodontic patients. Removable orthodontic appliances were used by 35% of the dentists and fixed orthodontic appliances by 18%. Twenty-six percent provided comprehensive orthodontic treatment, 22% aligned incisors, and 21% corrected anterior crossbites. The general dental practitioners surveyed provided a wide range of preventive and interceptive orthodontic services to a small percent age of their patients. Lawrence also assessed the dentists' satisfaction level with the

orthodontic services they provided. A minority of dentists wanted to treat fewer malocclusions or less difficult malocclusions. These were similar to the finding of Jacobson et al. (1991) where less than four percent of the dentists surveyed wanted to 'do less' orthodontics. Approximately 40% of the sample in this study would have liked to treat more orthodontic cases. Not wanting to treat fewer orthodontic cases was found to be associated with the provision of orthodontic services. This shows that dentists who were orthodontic providers wanted to maintain their current level of orthodontic service or increase it.

A large-scale study surveying all 196 AAO members in the State of Virginia was completed by Davidovitch in 1995. Twenty seven percent of the Virginia orthodontists reported they could use 81 or more new patients and 55% claimed that they were not busy enough. Of these orthodontists, 42% felt that a significant amount of orthodontics was being performed by non-orthodontists. Only 22% reported that no general practitioners in their area were providing orthodontic services, 19 % did not know and 16% replied that it was not applicable.

In 1981, Dugoni stated, "In California, 55% of the orthodontic care provided through prepayment programs is now furnished by non-orthodontists" (California Dental Service Corporation). In 1996, Wolsky and McNamara found that general dentists provide a substantial amount of orthodontic services to their patients. Only 23.7% of the 675 dentists in this survey reported that they provide no orthodontic treatment. Thus, the majority (76.3%) provides orthodontic services, with 19.3% providing comprehensive orthodontic treatment in Michigan. They concluded that

slightly less than one-third of orthodontic patients were treated by general practitioners, with an additional four percent treated by pediatric dentists. The percentage of general practitioners providing comprehensive orthodontic treatment in St. Louis reported by Foley 1988 was 19%, and was virtually identical to the findings of Wolsky and McNamara's study.

In 1999, Hans et al. also concluded that orthodontic specialists provide the majority of orthodontic services in Cuyahoga County, Ohio. He surveyed the dental and orthodontic experiences of tenth grade students. All high schools (n = 36) were contacted and twenty agreed to participate. Surveys were distributed in the classroom and data obtained for 2,808 students. Results of the survey revealed that 37% (1047/2808) received orthodontic treatment by 171 different providers. Of those treated, 73% (764 /1047) were treated by a specialists in orthodontics, 11% (118 /1047) were treated by a general dentists, 0.5% (7 /1047) were treated by a pediatric dentists, with 14% missing or unknown (158/1047).

In 1999, Eckhardt surveyed a randomly selected sample of general dentists in Ohio and he concluded that 76% of dentists reported that their practice has increased their overall patients' load, and there is no evidence that non-orthodontists were providing more and more orthodontic treatment. Of a total population of 6,151 dentists, 1,200 were targeted for participation, with a 57.5% response rate. Dentists were categorized into one of three groups reflecting the various level of orthodontic service provided: comprehensive, limited, and no treatment. An analysis of the result indicated that 11.3% of the dentists in Ohio render comprehensive orthodontic care,

21.3% provide limited orthodontic services and 67.4% provide no orthodontic care. These percentages were comparable to some recent studies but are significantly lower than findings of earlier investigators. Four and one tenth percent of the non-orthodontic specialists were treating between 1-10 patients, 5.5% were treating 11-50 patients, 1.8% was treating 51-100 and only 0.6% of the dentists were comprehensive providers to more than 100 patients.

Demand for Orthodontic Treatment and Dental Care

In industrialized countries, there is less need for restorative and prosthetic dentistry. For this reason many dentists are now offering preventive, more complex and specialized dental procedures, including orthodontic therapy. The boundaries between general dentists and specialists have become blurred over the years. (Linge 1987)

In 1976, the AAO evaluated the orthodontic utilization rate via survey information data collected from 4,883 high school seniors in geographically separated metropolitan areas. It was found that 22.9% of the population studied had received or were undergoing orthodontic treatment. Of these, 29.6% were treated by non-specialists. This survey also concluded that there would continue to be a reduction in child to orthodontist ratio and that "too many orthodontists are being trained to meet any logical projected demand for orthodontic services." (Williams 1977)

In 1990, Brown reported findings that showed that the percentage of people who indicated they visited a dentist within the past year increased gradually between 1983 and 1997. He suggested that more Americans were visiting a dentist while

demand for dental care increased overall across educational, racial and economic lines.

In 2001, Chadwick reported that he saw a "distribution problem" rather than a "lack of dental professionals needed to serve the dental needs of this nation." In 2001 there are more eleven–year-olds in the United States than at any other time in history, and this number will remain high for the next ten years. Although this almost guarantees the need for increased care, the number of dental school graduates began to decline from a high of 5,756 in 1982 to a low of 3,778 in 1993, a decrease of 34%. As a result, the dentist-to-population ratios started declining around 1995 and have continued to fall slightly ever since.

According to the household data of the 1987 National Medical Expenditure Survey (NMES), Americans underwent approximately 355 million dental procedures in 1987, with approximately eight percent for orthodontic treatment. Less than 50% of Americans visited a dental office. Those who did made approximately $292 million dental visits, and received approximately $30 billion worth of dental care. Of this total $10 billion was paid by insurers, $17 billion was paid out of pocket and $1.6 billion was not reimbursed. Although the dental care market is substantial, many Americans still do not visit a dentist. According to the 1996 Medical Expenditure Panel Survey (MEPS), slightly more than three percent of the American population visited a dentist to receive orthodontic care between 1987 and 1996. Overall, the rate of orthodontic utilization for individuals remained constant from 1987 to1996.

Previously, little information existed concerning the community demand for specialty services. In 1990, Stewart et al. surveyed dentists in the state of Victoria, Australia. The results revealed that half of the orthodontists reported an increase for their services and the other half claimed that there was a decrease or no change in their demand. Interestingly, many of the general practitioners who were surveyed about their orthodontic services reported an increase in the demand for orthodontic treatment. (Stewart et al. 1990)

There has never been a better time to be an orthodontist (McDonald 2001). The United States population is 270 million and there are 9,400 orthodontists; an average of one orthodontist per 30,000 people. Orthodontics has also gained widespread acceptance and affordability. Additionally, more orthodontists are retiring than graduating, interest rates are low, and more adults are seeking treatment. Most importantly, the U.S. birthrate is projected to continue to rise thru 2050 due to what is called the Echo Boom; the Baby Boom generation is having children.

In 1994, Wheeler and McGorray et al. examined the orthodontic need and demand in third and fourth grade children (n = 3696). Data including age, sex, race, orthodontic demand and need, socioeconomic status, availability of specialist treatment services, as well as thorough occlusal data were collected. Orthodontic demand was significantly higher in girls (9.5%) than boys (6.8%), whereas need was slightly greater for boys (41.8%, 44.2%, respectively). There were no meaningful differences in age when comparing the demand, and need. Demand was greater in white than in black children (11.8% versus 1.2%): Need was also observed to be less

in black (35.3%) than in white children (47.2%). Demand was greater in the urban schools (8.9%) compared to rural schools (6.3%), whereas need was found to be similar. There was more demand in the higher socioeconomic groups (11.7%) than in the lower groups (1.8%), whereas need was similar in all the groups. The demand group had a significantly greater number of orthodontists within a radius of five miles of the school than the need and no need groups.

The 1993 publication of the American Dental Association (ADA) lists professionally active orthodontists (including clinical practitioners, dental school faculty or staff, armed forces dentists, government employed dentists at the federal, state or local levels, interns and residents, and other health or dental organization staff members). Between 1982 and 1987, there was an increase of 555 professionally active orthodontists (a 7.1% increase) and an additional increase of 553 professionally active orthodontists between 1987 and 1991 (a 6.7% increase). Overall, between 1982 and 1991, the number of orthodontists increased from 7833 to 8941. During this period, there were comparable increases in the general population resulting in minimal changes in the ratio of orthodontists to population. (From 3.4 to 3.5 orthodontists per 100,000 individuals) (Waldman 1994)

Location of Practice

In 1996, Wolsky and McNamara performed a study that examined whether practice location contributes to the general dentist's decision to provide orthodontic services. They hypothesized that dentists in more rural areas may be faced with an unmet demand for orthodontic services because orthodontic specialists are not located

in their vicinity. The results of the study indicate there was no statistically significant relationship between the decision to provide orthodontic services and the distance in miles from the closest orthodontic office or the number of orthodontists within a ten-mile radius. The geographic factors appear to have no significant relationship to the amount of orthodontic services provided by general practitioners.

In 1999, Eckhardt concluded from his study that the distance from an orthodontist has no effect on whether or not general dentists provide orthodontic care. He looked at whether the proximity of an orthodontic provider influenced a general dentist's decision to provide orthodontic care. He determined the number of active orthodontists within a ten-mile radius of a general dentist's office. The results found that 4.8% of the general dentists were not near any orthodontists, 44% were close to 1-5 orthodontists, 24% were close to 6-10 orthodontists, 16.1% were by 11-20, 9.2% were near 21-50 and 1.3% of the dentist reported being within ten miles of more than fifty orthodontists. Whether the general dentist provided comprehensive, limited or no orthodontic care, a statistically significant relationship was not found as percentages were fairly evenly distributed across these three provider groups.

Chair Time of Treatment

In 1989, Gorczyca reported that general practitioners devoted 1.6% of their time to orthodontics while pediatric dentists allocated 19.7%. Also, the orthodontic services accounted for 1.1% of the general practitioner's income compared to 21.4% for the pediatric dentists.

In 1995, the AAO surveyed its 196 members from the State of Virginia. The study yielded a return rate of 93%. The majority of the group reported that they practiced 29-32 hours per week, and 66% said they used three to six chairs for patient care.

The average chair side time and duration of treatment were estimated by Bergström, in 1998, who studied nineteen years-old individuals treated by general practitioners (GPT) and specialists (SPT) within the totally subvention Swedish system for orthodontic care. He found that the average chair time was 212 minutes in GPT cases compared with 431 in SPT cases ($P < 0.001$). The duration of active treatment was, on average, 18 months in GPT cases and 23 months in SPT cases ($P < 0.01$). The average number of visits was 14 in GPT cases compared with 22 in SPT cases ($P < 0.001$). In GPT cases, the time invested in treating cases was less than for SPT cases. Bergström's explanation for these results was that difficult GPT cases with poor outcomes could have been discontinued or referred to a specialist. It is unlikely that more chair side time invested in GPT cases would have resulted in a better outcome. Besides, orthodontists treated patients on average thirty-two hours per week, while general practitioners treated orthodontic patients only two hours per week according to Moore's 1998 findings.

According to Eckhardt's study, (1999) the majority of the non-orthodontic specialists doing comprehensive or limited treatment, 82.6% and 71.1% respectively, spend between 1-25% of their practice time providing orthodontic care.

Utilization of orthodontic treatment

In 1998, both Le and Armogan examined the utilization of orthodontic services in Cuyahoga County, Ohio. The sample in this study consisted of tenth graders attending school and a total of 1,360 students were enrolled in the study. Thirty-two percent of the sample had previously received orthodontic treatment. In addition, Armogan found socioeconomic status to be an important cofactor in the utilization of orthodontic services. Students from higher socioeconomic groups were more likely to have family dentists, to have worn braces, to visit a dentist in the previous year, and to have been more compliant in terms of following through on a dentist's recommendation for orthodontic treatment.

According to the Hans et al. study in 1999, they concluded that the recommendation of a general dentist positively influences the utilization of orthodontic services. Of all 2,808 samples, 84% (2,371/2,808) had seen a dentist within the last year and 37% (1,047/2,808) of the students had received orthodontic treatment in Cuyahoga County Ohio. The mean age was 15.5 years with a standard deviation of 0.8 years. The male-to-female ratio was 1:1. Several interesting findings came out of this study. Within 84 % (2371/2808) of the students reported having visited a dentist within the last year, 78% of these cited checkup or prophylaxis as the reason for going. Seventy two percent of the students reported having a family dentist. From his sample patients who had seen a dentist within the last year were more likely to have had orthodontic treatment. When asked if they had been told that they needed braces, 42% reported positively and 45% reported negatively. Among the

42% that were told they needed braces, 71% followed through with the recommendation and obtained treatment; among the 45% that were not told they needed braces, only 7% eventually received orthodontic treatment by tenth grade. Of those that received orthodontic treatment, 87% were treated by orthodontic specialists.

Referral Pattern

According to McDonald (2001), 50-60 % of referrals are from general dentists.

Referral patterns vary from each study, Brin (1990) found 19.5%, McKnight (1995) found 42% of general dentists refer all of their patents, and Eckhard found 61% of general practitioners refered1-10 patients a month. Little (1974), Brown (1982) and Moyers (1990) show positive correlations with education, Stewart (1990) showed a no correlation. Lawrence (1995) and Eckhardt (1999) showed those who provide orthodontic services clearly referred significantly fewer patients to orthodontists, and Wolsky (1990) also showed no correlation.

In 1974, Little compared graduates from two different dental programs. One school provided dental students with a strong predoctoral orthodontic education, while the other university provided minimal education in orthodontics to dental students and "protected the specialty." It was shown that the graduates from the school, which gave the most instruction, referred more patients to the orthodontists, and a larger proportion conveyed a greater interest in orthodontics. The long treatment period for orthodontic patients makes securing meaningful clinical experiences for dental students difficult, but to refrain from teaching them the

fundamentals level gave an unfavorable impression: Dental students interpret the limited orthodontic material as confusing; they thought the instructors were "holding out on them"' or they thought the instructors did not know how to teach. Unfortunately, dentists who graduate with these negative attitudes are vulnerable to "hucksters" who promise simple answers to complex orthodontic questions. Orthodontic education should provide dental students with a positive experience and the necessary skills to make sound treatment decisions for the good of the patients. How this can be done is a matter of debate.

In 1984, Gottlieb discussed the preservation of the referral source orthodontic practice. In his article he mentioned that an orthodontic practice is dependent on referrals for new patients, although orthodontists are finding it increasingly difficult to get referrals in the traditional ways because of professional competition. A growing number of general dentists competing for a decreasing amount of traditional general dental work, and a growing number of general dentists and pedodontists turning to orthodontics as a source of income are affecting the referral pattern.

In 1990, Stewart et al. demonstrated that there was an increase in the enrollment of general dentists in short courses in orthodontics and a reduction or complete elimination of referrals by these dentists to orthodontic specialists. This implies that many of the general practitioners were providing orthodontic treatment themselves.

Several publications suggest that the more a general dentist provides orthodontic treatment, the greater will be the generalist's awareness of orthodontic

diagnosis and treatment as well as his or her own limitations in providing orthodontic services. It is hypothesized that involved practitioners become more likely to recognize difficult orthodontic cases, leading to increased referrals to orthodontic specialists. This view is supported by the writings of Smith and Moyers (1990). Furthermore, they all believe that because orthodontic diagnosis and treatment skills are complicated, they must be learned over time. An increased amount of time spent digesting concepts in diagnosis leads to a greater appreciation for the complexity of orthodontic diagnosis and treatment.

The results of Wolsky and McNamara (1996) showed general practitioners referred one to four patients to the orthodontist each month, regardless of the complexity of the services they provided. Dentists in the comprehensive category, however, referred fewer patients to the orthodontic specialist than those in the limited and none in the orthodontic provider group. Referral patterns also indicated that dentists in the comprehensive orthodontic provider group had a decreasing number of referrals over the past five years when compared with those in the limited and non-orthodontic provider group.

Brown et al. (1982) investigated factors influencing the amount of orthodontic treatment attempted by recent graduates of two British dental schools. They surveyed 279 graduates from theses two schools between the years of 1973 and 1975. Interestingly, they found that three quarters had been involved with six or more orthodontic patients since graduation, with a direct correlation between confidence in ability and provision of orthodontic care. Attendance at continuing education courses

by general dentists and provision of orthodontic care were also found to be positively correlated. With regard to referring patients, a third to a half of the general dentists recommended 75-100% of their orthodontic age patients to seek the care of an orthodontist. Approximately another third were found to refer 24% or less. This suggests a referral trend that follows a "nearly all" to "almost none" pattern. Similar results were reported by Sheiham et al. (1971) and Pender (1979). Over half of the general dentists were prepared to treat only 24% of their orthodontic patients without the advice of specialists.

In 1991, Jacobs and Bishara found that only 4.7% of the respondents reported that they did not refer any patients to orthodontists. The majority of respondents (51%) referred one to four patients per month, 34.2% referred five to ten patients per month, and 8.5% of the respondents referred more than ten patients per month.

In 1993, McKnight-Hanes et al. surveyed two thousand general dentists and pediatric dentists. Thirty–three percent of the general dentists replied compared to 49% of the pediatric dentists. Major differences were seen between two orthodontic services rendered by these two groups. Fifty-two percent of the general dentists referred all orthodontic care compared to only three percent of the pediatric dentists. Ninety-one percent of the pediatric dentists provided limited orthodontic care compared to 42% of the general dentists. Comprehensive orthodontic treatment was provided by 51% of the pediatric dentists and only ten percent of general dentists. These findings suggested that pediatric dentists provide orthodontic services more often than general dentists.

McComb et al. (1995) surveyed 149 general practitioners in the UK to assess their perceptions of orthodontic services. One hundred twenty-one surveys (90%) were returned. This group reported that 67% of the practitioners did not provide orthodontic services. Those who provided orthodontic treatment finished an average of 10.43 cases a year, while twenty-six percent did not refer any patients at all. The factors influencing the general dentist's choice of orthodontists for referral were as follows: standard of treatment (67%), length of waiting list (62%), personal knowledge of orthodontist (60%), ease of access for patients (57%), ease of making first appointment (49%), Difficulty of treatment involved (33%), standard of orthodontists' report (14%). Interestingly difficulty of treatment involved was of little concern. Fifty-two percent of the general dentists were dissatisfied with the services provided by the specialists.

In 1995, Lawrence found there was no significant difference between referral patterns of general dentists who are treatment providers compared to general dentists who do not provide orthodontic services. This was in contrast to the results of Jacob et al. (1991) and Eckhardt (1999) who found dentists that provide more orthodontic services referred significantly fewer patients to orthodontic specialists. Eckhardt's study showed that approximately 66.1% of the practitioners who provide comprehensive orthodontic care, reported that they refer between 1-10 orthodontic patients a month and 27% reported that they did not refer any at all.

Outcome Assessment of Education

Generally associated with outcome assessment is a shift in focus from controlling the "process" of education in favor of emphasizing control and measuring the "outcome" or "product" of education (i.e., the assessment of what comes out) (Behrents 1994). To translate this essence into a standard dental argument, Behrents gave an example using the new approach. It does not matter whether a school assumes (i.e., requires) that it takes five or five million amalgams to make a student competent in placing amalgams; but, it is important, regardless of whether the requirement is five or five million, that the school demonstrates, in the end, that the student is competent in placing amalgams. Thus, in this new scheme," process" is of lesser importance and measuring the" product' of the educational experiences is of greater importance. Measuring the end product-how much a student has learned and can the student apply the knowledge- requires new structure in terms of assessment.

In 1976, The Council on Dental Education addresses these standards:

1. Students will be able to recognize, classify, and differentiate occlusal problems of children and adults.

2. Students will be able to develop suitable treatment plans for patients to be treated in general practice and will possess those skills to deliver necessary care embodied in the treatment plan that is, mechanical needs, appliance design and prescription, clinical management of appliances and patients, fabrication of fixed and removable appliances.

3. Students will be able to select and treat patients with uncomplicated tooth malpositions and refer patients with more severe problems to orthodontists.

The ADA Commission on Dental Accreditation's Guidelines for Teaching Orthodontics in Dental Education, developed six goals for improvement of the undergraduate orthodontics curriculum:

1. Increase predoctoral students' exposure to clinical diagnosis of occlusal problems from the orthodontist's perspective.

2. Include additional instruction in cephalometric analysis.

3. Integrate orthodontic theory and principals into general oral diagnosis and treatment planning.

4. Encourage and facilitate predoctoral students' participation in treatment requiring "minor tooth movement'" that is, comprehensive-care Pediatric and adult patients who would be treated most properly in the general practitioner's office.

5. Increase predoctoral students' laboratory experience in the fabrication of orthodontic appliances.

6. Provide a course in human growth and development.

As a result of the committee's review of these recommendations, the following changes were made in the undergraduate curriculum

1. A 10-hour lecture series in human growth and development was added to familiarize the student with basic mechanisms of human growth and development related to diagnosis and treatment planning in orthodontics and pediatric dentistry.

2. A preclinical orthodontic course was established to provide information about wire-bending techniques, fabrication of basic orthodontic appliances, banding procedures, mixed-dentition arch-length assessment, and cephalometric analysis.

3. Laboratory exercises were added to able students to construct a removable acrylic appliance and a fixed removable lingual arch. Each student is afforded an opportunity to perform a mixed-dentition arc-length assessment, make a cephalometric analysis, and practice wire-bending procedures.

4. The existing 30-hour lecture series in orthodontics was revised to provide students with a basic understanding of the specialty of orthodontics at a level appropriate for the competent practice of general dentistry.

The undergraduate dental student has a central role to play in the future of orthodontics. Dougoni (1981) stated that

> "If we as orthodontists really believe that clinical comprehensive orthodontics is beyond" lip service," orthodontics should be one of the best taught and most demanding educational experiences in the clinical curriculum. We must educate these emerging members of the dental community that we are good at what we do and that their patients with dent facial problems need our services. This means teaching the highest-quality comprehensive care and committing our most competent and impressive instructors to the undergraduate program."

In general, researchers who have investigated quality assurance including educational issues related to orthodontic services provision have found that orthodontic instruction at most schools accounts for less than four percent of the total instruction time. (McDuffie and Kalpins 1985).

In 1982, Pender he had a similar finding. He assessed the view of recent graduates on the undergraduate orthodontic curriculum and he compared graduates of the Welsh National School of Medicine, and University of London. A questionnaire was posted and the response rate was 50%. In total, 464 responses were obtained. When queried on their opinions regarding their undergraduate orthodontic training, he further found that

1. Less than adequate time was spent on the orthodontic course.

2. With the knowledge acquired, both of growth and malocclusion discernment was less than adequate.

> 3. Not enough time was spent on the more complex forms of treatment.
>
> 4. Insufficient time was spent treating patients.
>
> 5. The more cases that practitioners treated, the more inadequately they regarded the time spent on more complex forms of treatment.

A survey of sixty-two dental schools in the United States and Canada found that one-third of the institutions did not require a student to participate in an orthodontic clinical experience and that the average number of orthodontic clinical hours a student experienced each year of dental school was approximately eight. The amount and diversity of didactic courses taught as well as the kinds of clinical experiences students received varied widely across institutions (Nieberg and Sinclaire 1988). Moyers in 1990 also experienced these concerns, stating that orthodontic corrections require more time and appointments than the single treatment procedures as in most of dentistry.

> Orthodontics requires an extensive knowledge of facial growth and development to treat malocclusions correctly and thoroughly, and dentists entering practice have less background and competence in orthodontics than in any other specialized fields of dentistry. Quality assurance in orthodontics is not controlled by state or regional board. Competence in orthodontic theory and clinical ability are never tested at this level (Moyers 1990).

The study of Brin and Ben-Bassat (1990) showed that the more the graduate was involved in clinical orthodontics, the higher was his perceived adequacy of the theoretical training. While the majority reported that they were generally satisfied with the time allocated to the theoretical and practical topics, the number of lectures on certain topics was judged to be inadequate. These topics included diagnostic aids,

differential diagnosis, adult orthodontics, treatment timing and fixed appliances. Interestingly, more than 25% of the respondents reported that the time spent on laboratory procedures was excessive. The majority (67%) had not broadened their orthodontic knowledge since graduation, while 11% claimed that they had furthered their familiarity with orthodontics through self-education.

In 1994, Burton et al. compared the relative amounts of time spent on the theoretical, practical and clinical components of the programs and also evaluated the nature of appliance therapy undertaken by the students. He compared the undergraduate orthodontic education in two dental schools, The University of Toronto in Canada and The University of Liverpool in England. In terms of clinical experience, the outcome was assessed by means of a questionnaire gived to 288 students in Toronto and 110 students in Liverpool. A personal interview was also used to clarify details of the nature of appliance therapy. The overall response rate was 69.7%, although it should be noted that the response rate of the senior students in Toronto was only 40% in comparison to the 84.1% from the Liverpool students. Both courses were compared from more than 250 hours of teaching, of which over 100 hours involved clinical instruction. Also both courses provided instruction in removable and fixed appliance therapy. It was found that undergraduates treated their own patients with both simple and complex appliances over a two-year period. While it was found that Liverpool students treated more patients per student than their counterparts in Toronto, they treated more cases in their third year with removable appliances and 'extraction only'. The treatment patterns employed in Toronto used

more headgear and functional appliances. They found that both of the programs had functional appliances and found that both of the programs had above average course hours allocated to the instruction of orthodontics. Toronto had 258 hours while Liverpool had 273 hours allocated for undergraduate orthodontic instruction. The authors cited studies that estimated the British experience to be about two-hundred hours, while the mean for Canadian and US schools was eighty-six hours. The authors also cited literature that demonstrated both lack of confidence and lack of experience as the primary reasons why general practitioners do not undertake orthodontic treatment. They concluded that, even though the exposure to orthodontics was limited in the undergraduate programs, a wide-ranging program might enhance the abilities of the practitioner to refer wisely and respond appropriately to continuing education programs.

In 1999, Brightman et al. assessed the outcome of predoctoral orthodontic dental education in an American dental school and results showed that graduating fourth year dental students do not possess the enough clinical skills to recognize orthodontic problems. Select questions from recent national board examinations in orthodontics were used to assess the student's ability to diagnose and didactic ability. The records of seven children with different types of malocclusion were selected from the practice of a board-certified orthodontist and were presented to dental students who were asked to make diagnoses and recommendations for treatment. The percentage of students who answered correctly was: 30% of first year students, 30% of second year, 42% of third year, and 59% of fourth year students. This gradual

increase in the number of correct responses demonstrated that the didactic knowledge nearly doubled over the four years of dental school. Didactic knowledge was low for the first and second year at 30%, as results for random guessing would be about 25%, but the results increased with increasing education. The highest mean percentage for any group of students was approximately 74%, and the lowest was about 59%. The orthodontists' mean scores were between 90% and 95%. In general, the students could diagnose only very obvious problems and were unable to assess the severity of those problems. First year students answered 65% of the clinical assessment questions correctly, whereas fourth year students answered only 70% of the questions correctly. The students missed obvious problems including presence of maxillary transverse deficiency and problems with gingival health, and they did not recognize unusual dental conditions such as congenitally absent, supernumerary, or impacted teeth. The shortcomings demonstrated by this study are in the area of clinical education in recognition of problems, their severity, complexity, and the need for referral to a specialist for treatment. The results of the Brightman et al. study demonstrated that graduating fourth year students apparently did not possess the clinical skills to recognize malocclusion in children and did not know when to refer such patients to an orthodontist for treatment. Unless the general dentist is taught to recognize malocclusion in children and to understand the benefits of timely treatment, these problems will not be addressed. The predoctoral curriculum should provide the graduating general dentist with the ability to know when to refer, where to refer, and what to treat, for the well being of the patient. This is consistent with the concerns of

Jacobs (1990) and Lowe (1991) and with their recommendations concerning greater proficiency in orthodontics.

In 1999, Eckhardt inquired about the number of limited and comprehensive orthodontic cases treated while in dental school. The data revealed the majority (58.8%) of dentists did not treat any limited orthodontic cases while they were in dental school. Thirty-six and one-tenth percent treated between 1-3 limited cases, 4.3% treated between 4-6 patients, 0.6% treated 7-10 and 0.2% treated more than ten, limited orthodontic treatment cases while in dental school. The results indicated that a large percentage of dentists (65%) had never treated a limited orthodontic case while in dental school. When asked if their orthodontic education while in dental school was comprehensive and extensive, 59.7% strongly disagreed and 31.1% disagreed. As a function of provider type, this question was not statistically significant. Less than half (48.9%) felt they had learned enough while in dental school to differentiate between limited and comprehensive orthodontic care. Ironically, significantly more dentists in the comprehensive group reported that they were inadequately trained to differentiate between limited and comprehensive orthodontic cases while in dental school.

Continuing Education

General dentists, in recent years, have often enrolled in proprietary courses in orthodontics outside the mainstream of dental education. An increasing number of orthodontic short courses are sponsored by dental societies, orthodontic supply houses, general dentists and orthodontists. To the cynic, sometimes these courses

seem to exploit the dentist's desire to learn, for the promoter's profit. Some are offered with such excessive zeal for a single idea or technique that the objective educational perspective is lost. Others are weak because of the incompetence or lack of training of the teachers. No other field in dentistry has as many courses offered by outside "experts" as orthodontics. Therefore, an uninformed dentist may have difficulty in choosing a course worthy of his time and money.

Linge (1987) observed that most dental programs do not adequately train students for full responsibility in orthodontic care. With the scientific gains in all dental specialties, the depth of instruction into each individual field is thus somewhat limited. While continuing education courses may be attended to manage the deficit, experience indicates that training at the graduate level to attain the background and insight is necessary for successful orthodontic care.

According to Lawrence in 1995, two measures related to continuing education in orthodontics were found to be positively correlated with general practitioner (GP) providing orthodontic services. These were orthodontic continuing education course attendance and the frequency of use of various sources of information to keep up to date in orthodontics. In his study, approximately 36% of the dentists surveyed had attended a continuing education course in orthodontics. In 1990, Freer and Foster reported that 12.6% of their sample of Queensland dentists had attended an orthodontic refresher course in the last five years.

In 1991, Jacob et al, found that the number of orthodontic procedures provided increased with the number of hours of orthodontic continuing education

attended in Iowa. A similar relationship was found in this study, where dentists who provided orthodontic services appeared more likely to have attended continuing education courses than dentists who did not provide orthodontic services.

At the University of Nebraska, Moore and Erickson (1998) surveyed dental and orthodontic alumni for their opinions on predoctoral and continuing education in orthodontics during the period between 1956 and 1987. Most of both dental and orthodontic alumni participated in some kind of continuing education in orthodontics, with one-to-three-day courses being the most popular. General practitioners (GP) were more likely to attend comprehensive courses lasting months or years. Respondents were also asked whether they thought more comprehensive predoctoral instruction in orthodontics would result in more referrals from GPs to orthodontists. More than two-thirds of the GPs agreed or strongly agreed that teaching more comprehensive orthodontics would result in more referrals; 55% of the orthodontists disagreed or strongly disagreed.

The alumni were asked whether they thought continuing education in orthodontics increases, decreases, or does not change the number of referrals from GP's to orthodontists. More than 70% of the GPs said continuing education increases referrals, but the orthodontists were fairly evenly divided and the differences were again statistically significant.

In 1994, the Association of Orthodontist's Council on Education developed and sponsored the third in a series of national surveys to determine the status of graduate orthodontic education. It also included information on the didactic and

clinical material that was being taught to identify strength and weakness and to provide a basis for comparison on past and future studies. A survey questionnaire covering nine major areas—(1) program organization, (2) graduate students, (3) faculty, (4) staff, facilities and infection control, (5) clinical details, (6) treatment techniques, (7) research, (8) curriculum, and (9) program costs—was sent to all the graduate programs in the United States and Canada. Results showed that many programs increased their duration from twenty-four to thirty-months or greater with the number of thirty month programs increasing rapidly from six percent to 31% during these six years. This trend continued but slowed from 1989 to 1994, with 30-36-month programs comprising 39% of graduate programs. In 1994, 90% of the programs taught straight wire systems as their principal appliance compared with approximately 38% in 1983. Begg appliances now are used in only about a quarter of the programs, down from a third in 1983 and 1989 according to 1994 AAO survey. They are now used for only about 11% of graduate clinic cases compared with 23% in 1983.

The amount of continuing education received in each year was surveyed by Eckhardt (1999). The majority of general practitioners (69.5%) attended 21-50 hours per year, but 6.8% reported that they did not attend any CE courses pertaining to orthodontics. Thirty-two and three-tenths percent of the dentists attended between 1-10 hours per year, 4.2% attended 11-20 hours, 1.7% attended 21-50 hours, 0.6% attended 51-100 hours and two people (0.4%) reported that they attended more than 100 hours worth of CE courses a year aimed at instruction in orthodontics. Eckardt

concluded that a larger percentage of those dentists who provide comprehensive orthodontic services attended significantly more hours of CE courses in orthodontics per year.

Financial Aspect

In 1995, Lawrence found approximately 60% of the dentists surveyed stated that providing orthodontic services was financially rewarding. There was a statistically significant difference between the provider and non-provider groups ($p = 0.05$). Dentists in the provider group appeared more likely to believe that orthodontic service provision was financially rewarding. The expansion of orthodontics in general dental practice has been associated with increased income derived from the services.

Costs of Orthodontic Education

The cost of an orthodontic education is on the rise. The average in-state tuition for a junior resident rose from 1994 to 1999 by $4,100 to an average of $12,158 per year. Senior tuitions showed similar increases. Out-of-state tuition rose even more, by an average of $6,000 from 1994 to 1999 to an average of $16,973. Actual reported annual tuitions ranged from $0 to $38,000 per year. No survey to data has addressed student indebtedness. (2002 Keim) In another study, Rudolph (1997) evaluated differences between low cost programs (average cost $2,829 in-state, $3,975 out-of-state) and high cost programs (average cost $14,151 in-state, $17,483 out-of-state). Rudolph said that the future quality of orthodontic education is threatened by the very small number of residents entering academics, due in part to

the high cost of residency programs and the poor financial rewards of academia. There has been a recent "aging" of the orthodontic faculty in many programs which may be caused by the limited number of new younger faculty combined with the loss of many middle-ranking faculty to private practice. Clinical treatment has seen a significant increase in the number of non-surgical adult cases being treated, as well as the doubling of clinic fees over the past ten years. "High cost" programs appear to provide a greater breadth and depth of orthodontic education than "low cost" programs.

Diagnosis

Health care providers are often unaware of the imperfect reliability of the methods and data of clinical practice. Reliability of clinical measures in dentistry (periodontal health assessment, caries detection) remains as a major challenge to diagnosis, treatment planning, and assessing the outcome of differing therapies. In clinical orthodontics, the assessment of malocclusion remains problematic. Many specialists feel that it requires at least two years of additional training to diagnose and treat orthodontic problems competently.

The research showed that the majority of orthodontists do not think that general dentist has the necessary skills in diagnosing and treating complex orthodontic problems. In 1977, Turpin published his findings regarding orthodontics graduates in the United States between the years of 1971 to 1975 with sixty-four percent (895) of the surveys being returned. The results showed that 72% of the orthodontists perceived general dentists as not recognizing orthodontic problems, yet

they listed "general dentists providing orthodontic services" as the third reason for their lack of sufficient patients. (Turpin 1977)

In 1996, Keeling examined the reliability among seven orthodontists in judging dental and facial aspects of malocclusion in a screening of elementary school children. Data included measures typically recorded during a clinical orthodontic examination: facial assessment of skeletal/incisor relationships and individual measures of morphologic malocclusion. Median kappa statistics indicated that the reliability of maxillary and mandibular antero-posterior positions, incisor exposure, interlabial gap, and maxillary crowding was poor ($K < 0.40$). Acceptable reliability existed for mandibular anterior crowding, facial convexity, overbite, overjet, and molar classification (median Kappa ranged from 0.48 to 0.72). Excellent reliability existed only for evaluating the presence of a posterior cross bite ($K = 0.79$). The results caution that the language of clinical orthodontic diagnosis is imprecise. In the Keeling study, the orthodontists were not randomly selected from a larger pool; therefore, results on reliability of individual measures cannot be generalized to all practicing orthodontists.

Outcome of Orthodontic Treatment

The assessment of outcome is complicated, judgment of outcome may consider the final alignment of the teeth, the difficulty of treatment, the initial need for treatment, the appropriateness of the treatment mechanics, the extent of any iatrogenic damage, and whether the final tooth positions are stable. A consideration of facial esthetics and the patient's satisfaction may also be important. Gottlieb

presented his accepted criteria for orthodontic correction in 1975 which included: Class I molar relation, class I cuspid relation, cusp interdigitation, overbite, overjet, midline, rotation, crowding or spacing, arch form, torque and parallelism of roots.

Bergstorm, (1998) presented the following outcome criteria.

1. Reduction in treatment need
2. Degree of success (treatment result)
3. Treatment stability
4. Treatment desire
5. Amount of deviation from ideal tooth relationships

Berg, (1991) classified criteria using following orthodontic treatment results;

1. Occlusion
2. Function of the stomatognathic system
3. Esthetics
4. Orthodontist's opinion
5. Patient's opinion
6. Stability
7. Iatrogenic treatment effects

Starnes (1996) stated that orthodontic treatment could never be finished to a perfect result. The decision to terminate treatment, unless it is forced by the patients or outside circumstances, is based on a subjective evaluation that can vary from one clinician to another. There is no official standard of treatment results to which

orthodontists have to confirm. Thus, every orthodontist needs some system of self-evaluation to maintain high standards.

Case Difficulty

In 1998, Bergstrom reported that orthodontists take on more difficult cases than general dentists. The quality of orthodontic care provided in three Swedish counties has been professionally evaluated in a series of studies of young adults (Bergstrom and Hailing 1996a, b; Bergstrom et. al. 1997). He reported treatment difficulty and treatment outcome of 19-year-old individuals treated by general practitioners or specialists within the totally subventioned Swedish system for orthodontic care. About one-quarter of the treatment evaluated was classified as easy, one quarter as moderately difficult, one-half as difficult among a total of 313 individuals who were evaluated according to treatment outcome and treatment assessment. More than one-quarter of the treatments provided by general practitioners were classified as difficult compared with three-quarters of those provided by specialists. It was found that the outcome measures in general were more favorable for specialist treatment than for treatment provided by general practitioners, in spite of the fact that the patients that specialist treated were on average classified as more difficult than those treated by the general practitioners. Bergstrom stated that since treatment difficulty influenced the outcome of orthodontic treatment. the process of selection of patients to be treated by a specialist or by a general practitioner is crucial

In 2000, Nguyen reported similar findings. He examined the pre-treatment occlusal characteristics of a cross-sectional sample of orthodontic patients treated by general dentists and orthodontists in Cuyahoga County, Ohio. He evaluated the cases using the IOTN and the PAR index. Ten general dentists and ten orthodontists were randomly selected from a pool of practitioners who were named as orthodontic providers for a representative sample of tenth grade students in Cuyahoga County who have had or were in treatment in 1998. Four hundred and five pre-treatment study models were evaluated from general practices, and 365 were evaluated from specialist practices. He found that general dentists and orthodontists treated similar patients with respect to age and gender, and he found no significant difference in mean PAR scores of pre-treatment study models of patients treated by general dentists compared to orthodontists. He did find that the IOTN esthetic component score of pre-treatment study models of the patients treated by general dentists was greater than the IOTN of patients treated by orthodontists. He concluded that the PAR and the IOTN probably measure similar characteristics of occlusion but with different objectives.

Satisfaction

Self-perception is influenced by the societal esthetic norms but is also related to psychological factors and personal factors for dental attractiveness. Students in social psychology indicated that physical attractiveness plays a major role in social interaction and influences the impression of an individual's social skill as orthodontic treatment improves facial apprearance. It is known, however, from studies in

children and adolescents that some persons with pronounced malocclusion are content, whereas others express concern about minor irregularities. Considerations other than structural factors apparently influence the person's response to his or her dental appearance. Inaccurately perceived tooth position has been demonstrated to be one such consideration especially in childhood populations. (Baldwin1980)

In 1991, Espeland studied 130 young adults (mean age 18.1 years) about their perception of their own occlusion. He found that the majority of the young adults (63%) in his sample were characterized as having near-ideal occlusion or only minor deviations. Only mild and moderate malocclusions were present in the sample since severe malocclusions are routinely treated during childhood. The subjects were generally aware of anterior traits. Almost all the subjects (98%) with near-ideal occlusion or minor deviations expressed satisfaction. Malocclusion was present in 14 of the 16 subjects who were dissatisfied based on realistically perceived anomalies. However, traits rated as malocclusion were present in 30% of the satisfied subjects, which may in part be explained by the mild degree of malocclusion in the sample. Awareness of occlusal traits varied among the satisfied subjects.

In 2000, Birkeland assessed the relationship between occlusion, satisfaction with dental appearance, and self-esteem at the ages of 11(T1) and 15 years (T2), and to study perceived treatment effects. The dental casts of 224 children were collected at T1 and T2 and assessed by the Aesthetic Component (AC) and Dental Health Component (DHC) of the Index of Orthodontic Treatment Need (IOTN), and Peer Assessment Rating (PAR) Index. At T2, sixteen children had been treated with

removable and fifty-one with fixed appliance, while 157 were untreated. The children in the fixed appliance group had better dental aesthetics (AC) and Occlusion (DHC) than those in the two other groups. Average PAR score reduction was 71.7% (T1-T2) and satisfaction with one's own or child's dental appearance increased significantly. The untreated group showed increased malocclusion. In spite of that, the children expressed higher satisfaction with their own dental appearance. Improvement in self-esteem from 11-15 years was not correlated with treatment changes.

Occlusal Indices

In 1899, Edward Angle developed the first qualitative measure of dental malocclusion when he constructed the Angle's classification of malocclusion. Massler and Frankel (1951) were among the first to place a qualitative assessment of dental malocclusion by mathematical measures in all three planes of spaces. However, conventional orthodontics recognized a need to reduce subjectivity in the assessment of malocclusions by quantifying the severity of the dental malocclusion, which gave the rise to occlusal index. In 1971, Provich and Thompson described the difficulty in quantifying the degree of malocclusion. One can assess it only by measuring the relationship of the teeth to each dental arch individually and their interaction with the maxillary and mandibular arches simultaneously.

Occlusal indices have proven useful in assessing treatment outcome by comparing pre-treatment and post treatment scores. Indices have also been used to compare various treatment modalities as a measure of treatment success and as a

personal audit of orthodontic treatment results. Furthermore, indices that grade the severity of case may be used as indicators for treatment. Qualitative indices were developed in the following chronological order listed in the Table 1.

Table1--Development of Indices

1899 Angle	Classification of molar relationship
1932 Stallard	General dental status; some malocclusion traits. No definition of traits given.
1945 Sclare	Record the presence of certain malocclusion traits: a) Molar relationship b) Arch constriction c) Protrusion of incisors d) Labial prominence of canine e) Lingually displaced incisors f) Rotated incisors g) Cross bite h) Open bite or closed bite
1957 Poulton and Aaronson	Occlusal Feature Index (OFI)
1959 Van Kirk and Pennell	Malalignment Index
1960 Draker	Handicapping Labio-Lingual Deviation
1964 Bjork et al.	Objective assessment of malocclusion based on defined-three areas of assessment: a) Dental anomalies: tooth anomalies, abnormal eruption, alignment b) Occlusal anomalies: sagittal, vertical and transverse deviation of the dental arches. c) Spacing or crowding
1966 Jamison and McMillan	No name
1967 Grainger	Treatment Priority Index (TPI)
1967 Howitt et al	Eastman Esthetic Index (EEI)
1968 Salzmann	Handicapping Malocclusion Assessment Record (HMAR)
1971 Summer	Occlusal Index (OI)
1974 Linder-Aronson	Swedish National Board for Health and Welfare Index.
1984 Behrents	Behrents Index

Table1--Development of Indices (Continued)

1986 Cons et al.	Dental Aesthetic Index (DAI)
1987 Richmond et al	PAR Index
1989 Brook and Shaw	Index of Orthodontic Treatment Priority
1991 Shaw et al	Index of Orthodontic Treatment Need (IOTN)
1995 AAO	AAO Objective Grading System
1998 Richmond	ICON

Shaw et al. (1995) defined an occlusal index as a rating or categorizing system that assigns a numeric score or alphanumeric value to an individual's occlusion. An index is a graduated scale that progresses from a lower limit to an upper limit, defining the progress of the disease from absence to terminal stages. The criteria of an ideal occlusal index have been described by various authors, but can be summarized as possessing the following features:

1. An index should be reliable and valid.

2. An index should be quick and easy to perform by a trained examiner, on patients or dental casts.

3. An index should be equally sensitive to all aspects of malocclusion.

4. An index should be amenable to statistical analysis and modification.

Assessment of the outcome of treatment or the changes resulting from treatment are a further potential use for occlusal indices. Several indices have been developed to evaluate treatment success.

Summer's Occlusal Index

In 1971, Summer introduced the Occlusal Index (OI), which was used in epidemiological studies and to determine treatment need. Nine occlusal characteristics were scored; dental age, molar classification, amount of overjet and overbite, posterior transverse and vertical problems, tooth displacement, missing teeth, and midline alignment. A score for each of these components was derived and weighted to calculate an overall score. The system was more appropriate for scoring pre-treatment rather than post-treatment study models because the index is made for measuring treatment need.

The Peer Assessment Rating (PAR) Index.

To develop an index of treatment outcome, a series of meetings with a group of 10 experienced Orthodontists was convened (British Orthodontic Standards Working Party). Study casts of various treated and untreated occlusions were examined and discussed until agreement was reached about the individual features that should be assessed to obtain an estimate of alignment and occlusion. A scoring system was developed and a ruler designed to allow analysis of a set of study casts in approximately two minutes.

To assess the extent to which the indices reflect current orthodontic opinion, a validation exercise was carried out. A panel of seventy-four dentists was enlisted, including twenty-two consultant orthodontists, twenty-two specialist orthodontic practitioners, eleven community dental officers, fifteen general dental practitioners, and two public health orthodontic administrators.

From the 1970's through the early 1990's the variation in criteria used by different orthodontists made it difficult to assess orthodontic treatment outcome. In 1984, the Department of Health and Social Security (DHSS) in Great Britain issued a report on unnecessary dental treatment being done in England. As a result of this report, the Occlusal Index Committee developed both the Index of Treatment Need (IOTN) and the Peer Assessment Rating (PAR) Index. Richmond et al. (1992) developed PAR index to record the dental malocclusion at any developmental stage, using a precise quantitative method of measuring malocclusion and efficacy of treatment. Today, both of these indices are used routinely as a standard of care for British orthodontic treatment in determining treatment need and treatment outcome, as well as for quality assurance and research. A scoring system was developed and a ruler designed to allow analysis of a set of study casts in approximately two minutes. The PAR index is applied to an individual's study models estimating deviations from an ideal occlusion. Scores are assigned to the various occlusal traits that make up the malocclusion with the individual scores summed to obtain a total that represents the degree a case deviates from normal alignment and occlusion. A final score of zero would represent perfect alignment and occlusion. Generally, a final score of ten or less indicates an acceptable alignment and occlusion. Higher pretreatment scores indicate a more sever malocclusion. Although there is no maximum initial score, these rarely exceed 50. The final score represents the amount the case deviated from normal occlusion," all anatomical contact points being adjacent, with a good intercuspal mesh between upper and lower buccal teeth, non-excessive over jet and

overbite." (Richmond et al. 1992a). The index is applied to both the start and the end of treatment study casts, and the change in the total score reflects the success of treatment in achieving overall alignment and occlusion.

Improvement is categorized into three grades according to specific criteria; "greatly improved" requiring a score reduction of at least 22%, "improved" requiring a reduction of at least 30%, and "worse or no different' categorized by a reduction of less than 30%. In 1999, Hamdan listed the limitation of this assessment

1. The high weighting for overjet may influence the index to such an extent that it is unduly sensitive in any malocclusion where overjet is increased.

2. A further limitation of PAR Index is that occlusions with initial scores of less than 22 points cannot become' greatly improved after treatment.

3. The zero weighting allocated to "displacements in the buccal segments which include impacted teeth (Brook and Shaw 1989) indicates that such irregularities are disregarded even though their correction may have a significant effect on treatment outcome.

4. Application of one weighting system to all malocclusions, since occlusal features vary in importance in different classes of malocclusion.

He examined PAR index validity using orthodontic consultant assessments as the goal standard and clinical ranking of occlusal features and statistical modeling to derive a new weighting system, separate for each malocclusion class. and he concluded that utilized a combination of point and percentage reduction in PAR score. This was found to have better correlation with the gold standard than PAR nomogram.

The objective of validation was to compare the PAR Index measurements against the subjective dental opinion of dentists for malocclusion severity (Richmond et al. 1992a). A panel of seventy-four dentists (forty-eight orthodontists and twenty-six general dentists) from England and Wales participated in the validation exercise and score 160 orthodontic cases using the PAR index criteria. Multiple regression techniques were used to weight statistically the various occlusal factors considered in the malocclusion. If a component did not have any predictive power in the assessment of the outcome, it did not receive any weighting. Eleven distinct components were identified. The weightings that were determined reflected British orthodontic opinion. Following the validation session of the panel of seventy-four British dentists, it was determined that maxillary and mandibular buccal segment alignment had no predictive power in severity of a malocclusion. Thus, four previously defined components were eliminated, reducing the number of scored components to seven. In DeGuzman's 1995 study, they also concluded there was no predictive effect in the difficulty of treatment of lower incisor crowding and therefore, upper anterior segment component did not receive a weighting. Presently, the PAR Index is composed of six scored segments and only five weighted components.

Richmond et al. (1992 a) discussed the reliability of the PAR index. He defined it as a tool that offers uniformity and standardization in assessing the outcome of orthodontic treatment. It's components were weighted to reflect current British

orthodontic opinion, however they could be changed to reflect future standards and standards in Britain and other countries, such as United States.

Buchanan et al. (1993) also evaluated the reliability of the PAR index by looking at the same sample originally used by Richmond et al. in 1992, when the index was developed, and compared it with the Summers Occlusal Index. They found that although the PAR index was simpler and easier to use than the complicated Summer occlusal index it did not diminish its validity and reliability.

DeGuzman et al. (1995) carried out a study to examine the reliability and validity of the PAR index by using the opinion of an American panel of orthodontists. A sample of 200 sets of study casts were examined by 11 orthodontists who rated them for malocclusion severity and perceived treatment difficulty. Multiple regression technique was used to evaluate the predictive power of the components of malocclusion on the patients' scores. Weightings calculated from the patients' regression coefficients and from the partial regression coefficients increased with the panel's opinion and the PAR index scores. As a result, the PAR index was considered to represent a good approximation of severity and treatment difficulty of malocclusion, and could be used as an outcome measure for the assessment of dento-occlusal changes.

Afsharpanah et al. (1995) assessed the effects of normal growth and development on the PAR index scores, by looking at study models of untreated subjects enrolled in the Bolton-Brush Growth Study. The respective mean PAR scores initial (T-1) and final (T-2) were 18.7 and 16.8. The results revealed that 84%

were "worse or no different," 16% were "improved", and no cases were "greatly improved". The authors concluded that normal growth and development resulted in an improvement in the occlusion in only 16% of cases.

Feghali et al. (1997) used the PAR index to assess orthodontic treatment outcome, where thirty-four pre-treatment and eleven post-treatment study models from the graduate orthodontic clinic at Case Western Reserve University (CWRU) were evaluated. Similarly, Hassanein et al. (1996), Mehizadeh et al. (1997), Beg et al. (1998), and Abei et al. (1999) also used the PAR Index in assessing treatment outcome. All these studies showed improvement in the cases at CRWU, where only four percent of the cases treated did not achieve over a 30% reduction of PAR score.

Holman (1995) scored pre-treatment and post treatment study models using the PAR Index to assess the outcome of orthodontic treatment in one hundred cases treated with the extraction of four bicuspids and in one hundred cases treated without extractions. The result showed that average treatment time for the extraction group was 29.7 months compared to 26.0 months for non-extraction treatment. The mean for pre-treatment PAR score were higher in the extraction group, 30.0 vs. 25.1, mean for both groups were 27.6. Although different at the beginning of treatment, both groups were statistically identical at the end.

Buchanan et al. (1996) used the PAR index to determine differences in outcome between the preadjusted Edgewise and Begg treatment techniques at the time of debonding. They noticed that a simple comparison of the percentage

reduction in PAR score may be misleading, and careful interpretation of the results is necessary.

Birkeland et al. (1997) compared pre-treatment (T1); post-treatment (T2), and five-year follow-up (T3) study models using the PAR index. They found that orthodontic treatment changed angle class I, II and III malocclusions to near ideal occlusion (PAR scores 4.4-6.8). The PAR score at the end of treatment had some explanatory importance for the long-term result; however, changes during the follow-up period were difficult to predict.

Fox et al. (1997) used the IOTN and PAR index to assess treatment complexity related to the occlusal changes, which occur during orthodontic treatment. The view of 280 practitioners towards recently completed cases was assessed and their attempts to define treatment were collected. They concluded that attempts to define treatment complexity identified factors, which were of questionable validity and easily manipulated in the practice setting.

Al Yami et al. (1999) evaluated the long-term orthodontic treatment outcome using the PAR Index, where dental study models were evaluated up to ten years post-retention. They concluded that the presence of a fixed retainer had a positive effect on the PAR score, where the relapse was 3.6 PAR points less at five years post-retention and 4.6 points less at ten years post-retention. From this study we can see how the PAR index was used to inform patients about treatment limitations in order to better meet their expectations.

The ABO Objective Grading System

In 1998 The American Board of Orthodontics (ABO) introduced their Objective Grading System. This precise method for orthodontic treatment evaluation was field-tested for objectivity in evaluating post-treatment dental casts and panoramic radiographs. It consists of a measuring gauge specially designed to detect for discrepancies in alignment, overjet, occlusal contact, interproximal contacts and occlusal relationships.

At the 1995 ABO phase III examination, one hundred cases were evaluated as first in a series of field tests. A series of fifteen criteria were measured on each of the final results showing that 85% of the inadequacies were found in seven of the 15 criteria (alignment, marginal ridges, buccolingual inclination, overjet, occlusal relationships, occlusal contacts, root angulations).

Therefore, at the 1996 phase III examination, a second field test was initiated to verify the results of the previous test and to determine if multiple examiners could score the records reliably and consistently. In this field test, a subcommittee of four directors evaluated three hundred sets of post-treatment dental casts and panoramic radiographs. Again, the majority of the inadequacies in the final results occurred in the same seven categories, but the committee had difficulty establishing adequate inter-examiner reliability. The subcommittee recommended that a measuring instrument be developed to make the measuring process more reliable. A third field test was performed using the modified scoring system with the addition of an instrument to measure the various criteria more accurately. All of the directors

participated in this field test, and a total of 832 dental casts and panoramic radiographs were measured. The results again showed that the overwhelming majority of the inadequacies in the finished results occurred in the aforementioned categories. However, the directors decided to add interproximal contacts to the scoring system to raise the total number of criteria to eight. In addition, modifications were made in the measuring instrument to improve measuring accuracy among directors.

The fourth and final field test was performed in 1998 to refine the measuring and calibration process, and to gather enough data on general performance to establish the validity or cut-off for passing this portion of the phase III examination. This field test was extremely successful. Not only did it reaffirm the benefits of using an objective system for grading the dental casts and panoramic radiographs, but also it helped to establish standards for successful completion of this portion of the phase III examination.

Based upon the collective and cumulative results of these extensive field tests, the Board decided to officially initiate the use of this Objective Grading System for candidates who were examined at the February 1999, ABO phase III examination in St. Louis.

During the 1997 and 1998 field tests, both subjective and objective methods of scoring the dental casts and panoramic radiographs were used by the directors. Based upon a comparison of these two methods, a passing score was established. In general, a case reports that loses more than 30 points will fail. A case report that

loses less than 20 points will generally pass that point of the phase III examination. However, this figure only represents part of the overall score for each case report. The quality of the maxilla, mandible, maxillary dentition, mandibular dentition, and facial profile are also carefully scrutinized. The Board is presently field-testing objective methods for grading these other aspects of the phase III examination.

Deflection Index

Dr. Rolf Behrents developed the Deflection Index at the University of Tennessee, Memphis. The Index is not weighted, as the PAR is, so that tooth movement could be purely analyzed without the introduction of other factors. The overall approach of this Index was to measure deviations from established normal values and simply sum up values in order to produce a number that represents the total distance that must be moved to achieve excellent intra and interarch placement of the teeth. The Deflection Index is consisted of 21 measurements obtained by electronic digital calipers (0.01 mm).

Table2. --The Deflection Index Measurements

1. Overjet	11. Mandibular intermolar width
2. Central incisor thickness	12. Crossbite
3. Net overjet	13. Right molar deflection
4. Overbite	14. Left molar deflection
5. Net overbite	15. Crowding upper
6. Open-bite correction	16. Crowding lower
7. Midline	17.Total crowding upper
8. Maxillary inter canine width	18.Total crowding lower
9.Maxillary intermolar width	19.Total crowding
10.Mandibular intercanine width	20.Total molar deflection
	21.Total deflection

STATEMENT OF HYPOTHESES

The purpose of the present study was to compare orthodontic treatment outcome of 126 cases treated by orthodontic specialists to 70 cases and treated by non-orthodontists using the PAR Index, the Deflection Index, the ABO Objective Grading System, and the Q-sort evaluation method.

The null hypotheses were:

Hypothesis I: There is no statistical difference in mean treated PAR score between dental casts of patients treated by orthodontic specialists and dental casts of patients treated by non-orthodontists.

Hypothesis II: There is no statistical difference in mean post treatment deflection index score between dental casts of patients treated by orthodontic specialists and the dental casts of patients treated by non-orthodontists.

Hypothesis III: There is no statistical difference in mean post treatment ABO Index between dental casts of patients treated by orthodontic specialists and the dental casts of patients treated by non-orthodontists.

Hypothesis IV: There is no statistical difference in mean Q-sort scores between dental casts of patients treated by orthodontic specialists and the dental casts of patients treated by non-orthodontists.

MATERIALS AND METHODS

Study Sample

Approval to collect data for this study was given by the Internal Review Board at Case Western Reserve University in December 1996. The survey data collected in 1997 and 1998 from 2,808, 10th grade students attending high school in Cuyahoga County were used. Of the 2,808 subjects, 1,046 or 37% were orthodontically treated. Impressions were taken on 890 of the 2,808 subjects; of these 255 were orthodontically treated subjects. Of the 255, 78 were treated by non-orthodontists, 160 were treated by orthodontic specialists, and 17 were unknown. Distortion of impression material and/or incomplete database information lowered the number of subjects in the impression sample to 196. Of these, 126 were treated by orthodontic specialists and 70 were treated by non-orthodontists. (Figure 1)

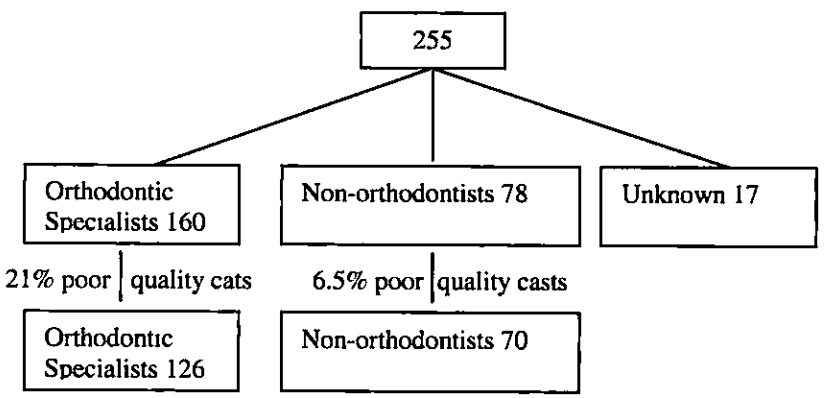


Figure 1. Sample selection

Using a randomizing table, 50 dental cases were selected from each group for use in the Q-sort Index. All 196 casts were used for the PAR Index, the Deflection Index and the ABO Objective Grading System scoring.

Data Collection

PAR Scoring

The technique for the PAR scoring dental casts has been previously published (O'Brien et al.1993). The primary investigator (Y.A) was calibrated in the use of the PAR Index. To be calibrated the primary investigator was asked to PAR score fifteen dental casts. And a another investigator calibrated by O'Brien (Roland Feghali) scored the same fifteen casts. The resulting scores were compared for reliability.

Each set of the 196 dental casts was hand articulated in maximum intercuspation without the use of a wax bite for reference. The primary investigator was blinded to the identification of the provider. Appendix 3 shows the data collection sheet used for this project.

The PAR score is comprised of six components each weighted by a factor according to difficulty of correction of malocclusion. In this study the American weighting system was used:

1. Upper Anterior segment (UAS) X1
2. Right Buccal Occlusion (RBO) X2
3. Left Buccal Occlusion (LBO) X2
4. Overjet(OJ) X5
5. Overbite(OB) X3

6. Centerline (CENT) X 3

The components are scored and multiplied by their factor. Then the "weighted scores" from the six components are added to obtain the total PAR score. The data were entered in to a Microsoft Excel® spreadsheet. (Appendix 4.5)

The Deflection Index

The technique for the Deflection Index has been previously published by Rolf Behrents (1993). This index is not to be weighted, so that tooth movement could be purely analyzed without the introduction of weighting factors. The primary investigator (Y.A.) was self-calibrated using a manual provided by Rolf Behrents. The Deflection Index is the sum of six components of recorded 21 variables; all measurements were made with electronic digital calipers calibrated to 0.01 mm. The overall approach to thie Deflection Index was to measure deviations from established normal values and then simply sum across variables in order to produce a number that represents the total distance teeth must be moved to achieve excellent intra- and interarch placement.

The index consisted of the following variables:

1. Overjet; the distance parallel to the occlusal plane from the incisal edges of the most labial maxillary central incisor to the most labial mandibular incisor.

2. Central incisor thickness; thickness from labial to lingual of the maxillary central incisor measures at the incisal edge.

3. Net Overjet; overjet minus central incisor thickness.

4. Overbite; mean overlap of upper to lower central incisors.

5. Net overbite; overbite minus 1mm (assumes that ideal overbite is 1mm).
6. Open-bite correction; in case with an anterior open bite, the mean distance from the incisor edges of the upper and lower central incisors.

7. Midlines; horizontal distance from the maxillary dental midline to the mandibular dental midline.

8. Maxillary intercanine width; distance between cusp tips or estimated cusp tips in cases of wear facets.

9. Maxillary intermolar width; distance between mesiobuccal cusp tips or estimated cusp tips in cases of wear facets.

10. Mandibular intercanine width; distance between cusp tips or estimated cusp tips in cases of wear facets.

11. Mandibular intermolar width; distance between mesiobuccal cusp tips in cases of wear facets.

12. Cross-bite correction; in cases with posterior cross bite, the amount of maxillary expansion necessary to correct the cross-bite.

13. Right molar deflection; deviation of the mesiobuccal cusp tip of the right maxillary first molar from the mesiobuccal groove of the right mandibular first molar. In the present study, in cases treated to a class II molar relationship (e.g., if a class II molar relationship was achieved), this measurement was assigned a value of zero.

14. Left molar deflection; deviation of the mesiobuccal cusp tip of the left maxillary first molar from the mesiobuccal groove of the left mandibular first molar. In the present study, in cases treated to a class I molar relationship, this measurement was assigned a value of zero.

15. Crowding upper; distance between each maxillary anterior contact point from the mesial of the first maxillary right premolar.

16. Crowding lower; distance between each mandibular anterior contact point from the mesial of the first mandibular right premolar to the mesial of the first mandibular left premolar.

17. Total crowding upper; sum of all upper crowding measurements.

18. Total crowding lower; sum of all lower crowding measurements.

19. Total crowding; sum of right and lower crowding.

20. Total molar deflection; sum of right and left molar deflection.

21. Total deflection= overjet+overbite+midline+openbite correction+total crowding+ total molar deflection.

Each set of study models was hand articulated in maximum intercuspation without the use of a wax bite for reference. The primary investigator was blinded to the identification of the provider. All measurements were made with electronic digital calipers calibrated to 0.01 mm, and scored in The Deflection Index Scoring sheet (Appendix 6). The data were entered into a computer-spread sheet (Microsoft Excel®. Appendix7 and 8) and analyzed.

The ABO Objective Grading System

The primary investigator (Y.A.) was self-calibrated using The ABO Objective Grading System self-calibration kits under the supervision of ABO director, Dr. Mike Riolo. The primary investigator, blinded to provider's identification of dental casts, scored each dental cast the ABO Objective Grading System score sheet. (see Appendix 10.) The data were entered in a computer-spread sheet (see Appendix13 and 14). The scores are given for the deviations from the ideal position. The final number was the arithmetic sum of all seven dental cast measures, plus the root angulations taken from panoramic radiographs, the actual ABO Index uses. In the present study, we could not collect root angulations measurement, since we did not have access to the panoramic radiographs for these patients.

The index consisted of the following variables:

1) Alignment

2) Marginal Ridges

3) Bucco-lingual inclination

4) Occlusal contact

5) Occlusal relation

6) Over jet

7) Interproximal contacts (see Appendix 11)

8) Root angulations*

*Root angulations were not assessed in this present study.

In general, a case report that loses more than 30 points will fail the ABO examination. A case report that loses less than 20 points will generally pass that point of the phase III examination. In addition to this classification, Dr. Mike Riolo suggested to classify cases the following groups:

- Less than 10 = excellent
- 11-19 = good
- 20-26 = probably pass American Board part III
- 26-30 = boarder line, may or may not pass
- 30-35 = Poor
- Greater than 35 =Very poor
- Greater than 45 = Extremely poor

Q-sort

This index was graded in three categories, Poor, Average, and Good. Written directions were distributed to the examiners who were all experienced orthodontic specialists.

> Directions: Please separate these 100 dental casts of orthodontically treated patients into three groups; A good treatment result, A average treatment result, A poor treatment result. Please place the "good" dental casts on the left, the "Average" dental casts in the center; and the "Poor" dental casts on the right.

All the examiners were blinded to the of orthodontic treatment provider. Each set of study models was hand articulated by the examiners in maximum intercuspation without the use of a wax bite for reference. Three groups were made by each examiner. This index was a subjective and, it relied only on the examiners` preference. Examiners classified models into three groups based on their own judgment. The primary investigator (Y.A) recorded each cast as "Poor", "Average" or "Good" on the Q-sort scoring sheet. (Appendix 14) For convenience, one point was given to the dental casts in the "Poor" group two points were given to the dental casts in the "Average" groups, and three points were given to the dental casts in the "Good" group. The data were entered in a computer-spread sheet. (Appendix15, 16) The numbers of the cases from each group were counted for each examiner individually. The number of "Good" cases "Poor" cases from two provider groups were compared using Chi-square to see if any of the examiners could tell the orthodontic specialists cases from non-orthodontic cases. (Table 8, Appendix 17)

Also total Q-sort points were compared by the sum of the score for each of the casts across all the examiners. (Table 9)

Data Analysis

All data were entered into a computer-spread sheet (Microsoft Excel®, Microsoft INC., Seattle, WA) by the primary investigator. The Statistical Package for Social Science (SPSS)® was used for statistical analysis. A p-value ≤ 0.05 was used to assign statistical significance. T-tests were used for all continuous variables including PAR, DI, the ABOI and Q-sort totals. A Chi-square was used for each Q-sort.

RESULTS

Total Sample

The final sample consisted of 196 sets of casts. Forty five percent were male and 55% were female. The mean PAR scores for all cases in the sample is given in Table 3. Each of the six components is listed along with their respective mean scores.

TABLE 3. --Post Treatment PAR Score (weighted)

N=196	Mean	Standard Deviation
Total	11.39	5.57
UAS	1.51	1.44
RBO	3.07	1.65
LBO	3.13	1.43
OJ	2.19	0.90
OB	1.21	1.78
CENT	0.30	0.90

USA· upper anterior segment, RBO Right Buccal Occlusion, LBO Left Buccal Occlusion, OJ Overjet, OB Overbite, CENT. Centerline

The mean PAR scores according to the two providers groups are listed in Table 4. There were no significant differences in six of the seven components that were assessed, but mean LBO was significantly greater in the orthodontic specialists.

TABLE 4. --The PAR Score (weighted) Compared by the Provider

Components	Orthodontic Specialists	Non-Orthodontists	P-value
Total	11.56 ± 5.60	10.85 ± 5.25	0.39
UAS	1.51 ± 1.51	1.53 ± 1.17	0.46
RBO	3.18 ± 1.50	2.86 ± 1.88	0.08
LBO	3.28 ± 1.35	2.87 ± 1.55	0.02*
OJ	2.12 ± 3.11	2.33 ± 3.02	0.33
OB	1.32 ± 1.83	1.03 ± 1.69	0.13
CENT	0.30 ± 0.30	0.30 ± 0.91	0.49

*Statistically significant $p \leq 0.05$

The Deflection Index

The mean scores for the total sample uses The Deflection Index are given in Table 5. The Deflection Index score between orthodontic specialists and non-orthodontists are shown in Table 6. The value does not show any significant differences. Total crowding scores did show a trend toward significance ($p = 0.08$).

TABLE 5. --The Deflection Index Score for the Total Sample

N=196	MEAN	STANDARD DEVIATIONS
Total	11.8	7.02
Overjet	2.82	1.17
Central incisor thickness	1.32	0.36
Net over jet	1.50	1.14
Over bite right	2.19	1.15
Over bite left	2.15	1.14
Openbite	0.04	0.28
Midline	0.63	0.76
Cross bite	3.32	3.35
Right molar deflection	0.91	1.28
Crowding upper	3.68	2.97
Left molar deflection	0.96	1.38
Crowding lower	2.80	3.23

TABLE 5. --The Deflection Index Score for the Total Sample (continued)

N=196	MEAN	STANDARD DEVIATIONS
Total crowding	6.50	5.60

TABLE 6. --The Deflection Index Score by Provider

	Orthodontic Specialists	Non-Orthodontists	P-value
Total	11.18 ± 7.50	13.0 ± 5.96	0.08
Over jet	2.74 ± 1.39	2.94 ± 1.32	0.23
Central incisor thickness	1.29 ± 0.40	1.40 ± 0.40	0.06
Net over jet	1.46 ± 1.13	1.56 ± 1.189	0.58
Over bite right	2.11 ± 1.12	2.33 ± 1.20	0.20
Over bite left	2.05 ± 1.09	2.34 ± 1.23	0.09
OP	0.04 ± 0.28	0.06 ± 0.29	0.75
Midline	0.61 ± 0.73	0.64 ± 0.77	0.81
Cross bite	2.46 ± 3.10	4.87 ± 3.25	7.48E-0.7*
Right molar deflection	0.86 ± 1.26	0.98 ± 1.33	0.54
Left molar deflection	0.92 ± 1.28	1.04 ± 1.54	0.26
Crowding upper	4.08 ± 2.47	3.47 ± 3.21	0.08
Crowding lower	3.17 ± 2.57	2.61 ± 3.53	0.12
Total crowding	6.08 ± 6.21	7.24 ± 4.23	0.08

The ABO Objective Grading System

The mean ABO objective grading system and standard deviation of post treatment study models was 27.27± 12.0 as shown in Table 7.

TABLE 7. --ABO Grading System Score

N=196	Mean	Standard Deviations
Total	27.27	12.0
Alignment	6.26	4.82
Marginal Ridges	4.09	2.90
Buc-lingul inclination	4.40	3.70
Occlusal contact	4.36	4.68
Occlusal relation	3.18	3.45
Over Jet	4.05	3.68
Interproximal contact	0.93	2.04

Table 8 reports the means and standard deviations of the seven components by provider group. A significant difference was found ($p < 0.05$) in the total mean score for The ABO Objective Grading System, and in the alignment section.

TABLE 8. --The ABO Objective Grading System Score by Provider Type

	Orthodontic Specialists	Non-Orthodontists	P-VALUE
Total	26.0.±11.4	29.6±12.8	0.04*
Alignment	5.39±4.37	7.8±5.21	0.0007*
Marginal Ridges	3.92±2.87	4.4±2.87	0.27
Buccolingual inclinatior	4.51±4.03	4.18±3.02	0.55
Occlusal contact	4.05±4.34	4.91±5.21	0.22
Occlusal relation	3.11±3.44	3.30±3.48	0.71
Over Jet	4.20±3.96	3.77±3.10	0.43
Interproximal contact	0.78±1.49	1.21±2.77	0.15

TABLE 9. -- The ABO Objective Grading System Score by Provider

SCORE	TOTAL		Orthodontic Specialists		Non-orthodontists	
	Count	Percentage	Count	Percentage	Count	Percentage
<10	4	2%	4	3%	0	0%
<20	49	25%	37	29%	12	17%
<26	55	28%	33	26%	22	31%

TABLE 9. -- The ABO Objective Grading System Score by Provider(continued)

SCORE	TOTAL		Orthodontic Specialists		Non-orthodontists	
	Count	Percentage	Count	Percentage	Count	Percentage
<35	44	22%	29	23%	18	26%
<45	26	13%	18	14%	8	11%
45<	18	9%	8	6%	10	14%
Total	196	100	126	100	70	100

Q-sort

Table 10 shows the Chi-square result from Q-sort. Only one examiner could detect significant differences between Non-specialists and specialists groups.

TABLE10. --Chi-square Results

Examiner	X^2	P-Value
1	2.91	0.08
2	3.87	0.04*
3	1.42	0.23
4	0.02	0.88
5	2.1	0.15
6	0.23	0.63
7	0.09	0.76
8	0.77	0.38
9	0.01	0.90

In order to pool the Q-sort results "1" was given for poor cases, "2" was given average cases, "3" was given for a good case. The sum of these numbers were analyzed by the t-tests. The results were shown in Table 11.

TABLE 11. --Q-sort t-test

	Orthodontic Specialists	Non-Orthodontists	P-value
Total	16.6 ± 4.75	15.4.±5.37	0.22
Average	1.85	1.71	

Correlation Between The PAR Index, The Deflection Index, and The ABO Objective Grading System

A Pearson correlation was calculated to assess the magnitude of correlation between each index. The results displayed in Table 12 shows that all four indices are correlated.

TABLE12. --Person Correlation Coefficients for The PAR Index, The Deflection Index, ABO Objective grading system, and Q-sort

	Q-sort	The Deflection Index	The ABO Objective Grading System	The PAR Index
Q-sort	1			
The Deflection Index	-0.47**	1		
The ABO objective Grading System	-0.58**	0.38**	1	
The PAR Index	-0.56**	0.51**	0.42**	1

(**P< 0.05)

Reliability

Approximately ten percent of sample was re measured to estimate reliability. The result of the Intra class coefficient was calculated to estimate reliability. The

results are listed in Table 13. The primary investigator (Y.A) showed the excellent reliability for all indices used.

TABLE 13. --Intra Class Correlation Coefficient

COMPARISON	RELIABILITY COEFFICIENT
PAR	0.96
ABO	0.94
Deflection	0.89

DISCUSSION

The purpose of this study was to compare orthodontic outcome treatment between patients treated by orthodontic specialists and patients treated by non-orthodontists. We used the PAR Index, the Deflection Index, the ABO Objective Grading System, and Q sorts to quantify dental alignment in patients treated by orthodontic specialists or by non-orthodontists. Statistical differences were found in the total score and alignment score for the ABOI.

The Peer Assessment Rating Index

The total PAR score found in the sample of treated case (n = 196) were 11.39 (sd = 5.57). This falls into "Generally Acceptable Range". When broken down by the individual PAR score components (Table 1), it was apparent that the highest scores among the cases were seen in the buccal segments, RBO and LBO. The lowest scores were seen in the centerline component. The similar trends were found by Red (1998). RBO scores are lower than LBO in both orthodontic specialists and non-specialists group; this might be due to the majority of right-handed orthodontic providers.

The means for the PAR score for orthodontic specialists and non-orthodontists were 11.68 ± 5.54, 10.85 ± 5.25 respectively. The non-specialists treated cases scored slightly lower, but there was no statistical significance in means of the total PAR score between these two groups, except left buccal occlusion shows significant difference (p = 0.02). This can be due to the impression technique. Interestingly,

Feghali (1999) found a trend toward significance between the total alginate and polybite impression (putty polyvinylsiloxane material) score along with the Left Buccal Occlusion component ($p = 0.083$).

The DeGuzman et al. study concluded lower incisor and buccal segment crowding did not have a predictive effect for malocclusion severity and perceived treatment duration. This opinion may have been influenced by the comparative ease with which dental crowding is corrected by extraction of teeth or arch expansion, in contrast to the more difficult correction of overjet or midline discrepancy. Treatment difficulty and malocclusion severity were distinct but related entities, although, various components of malocclusion were not reliable predictors of perceive treatment difficulty. From the point of outcome assessment on the contrary, the traits, which can be easily corrected, should be weighted higher, because the error in the easier part shows more inferiority than error in difficult traits to correct.

According to Richmond et al. (1992b), there are two ways of assessing improvement according to the PAR Index: the numerical reduction in the weighted PAR score and percentage reduction in the weighted PAR score. For a completed orthodontic case to be analyzed by the numerical reduction in PAR score, it is necessary to use the British weighting system that was developed during the first PAR validation session (Richmond et al. 1992a). However in this study the American weighting system was used (DeGuzman1995), we are supposed to use numerical reduction in PAR score, but we were not be able to use numerical reduction in PAR, since pretreatment dental casts were not available for this study so the aspect of

treatment difficulty is not considered in this study. This is an important variable, as it may affect treatment goals and in some instances may influence clinicians to accept an attainable but less than ideal treatment result. It is not totally fair to compare treatment out come only without judging case difficulty. Even though Nguyen (1999) showed no statistical significant difference in the mean pretreatment PAR score for cases treated by general dentists and orthodontists. (21.6 ± 9.3 and 22.2 ± 9.3 respectively), there is a possibility that numerical reduction in PAR score shows different result from the present study.

The Deflection Index

The deflection index requires 21 measurements measured by electric caliper. This really evaluates Overjet, Overbite, Midline, and Transverse deficiency in canine and molar lesion, Crossbites, Interdigitation of right and left molar, crowding upper and crowding lower. Total score of deflection index for orthodontic specialists and non-orthodontists were 11.18 ± 7.50, 13.0 ± 5.96 respectively. There was a trend toward significance ($p = 0.08$) between these two groups along with the total crowding.

Comparing with PAR, electric digital caliper is more accurate than the PAR ruler. Less than 1mm of the crowding and less than 3 mm of overjet evaluated by the PAR index will be zero and not significant. In addition to the PAR measurements, the deflection index scores upper cuspid to bicuspid and mandibular first bicuspid to first bicuspid crowding which are not evaluated in the PAR Index.

The Defection Index measures deviation from established norm (ideal occlusion), but validity for the established value can be argued. For example The Deflection Index set ideal overjet and overbite one millimeter. For the Overjet section both incisor should be touched for the ABO index, and 3mm for the PAR Index. (Appendix 19) Also, intra-arch measurements such as the interdigitation of the teeth, and the intercuspal relation are not evaluated by the Deflection Index but only first molar deviation is measured.

The ABO Objective Grading System

The ABO Objective Grading Index was invented for outcome assessment for the American Board of Orthodontics phase III examination. The eight criteria used for the ABOI were chosen by the ABO examiners. They used the measurements that cover 85% of mistakes that examiners see in the phase III examination. The ABO Objective Grading System was designed to evaluate finished cases and therefore was probably best index for the present study.

In the alignment section, maxillary central groove (mesiodistal) alignment and mesiobuccal cusps of the mandibular molar and premolars are assessed in addition to incisor alignment, and not only horizontal, vertical marginal ridge discrepancies, inclination of teeth, exact occlusal contact point, interdigitation of posterior teeth, overjet of all the teeth, those were not assessed by The PAR index, were assessed by this index.

The overall mean ABOI score was 27.27 ± 27. In general, a case score of 30 points will fail and less than 20 will generally pass that portion of ABO phase III

examination. Twenty-six is the borderline for passing examination. Additionally, the quality of the record, appropriateness of the treatment plan, and objective for position of the maxilla, mandible, maxillary dentition, mandibular dentition, and facial profile are also scrutinized. In the present study, root angulations were not measured; adding root angulations measurement section makes the score higher than 27.27 ± 27. A significant difference was found ($p \leq 0.04$) in the total ABO score between orthodontic specialists and non-orthodontists. The alignment score which was highly significant ($p = 0.007$) shows that orthodontic specialists are superior in straightening posterior teeth. In addition to anterior teeth alignment that both PAR and Deflection indices evaluate, ABOI alignment section examines the central groove (mesiodistal) alignment in Maxillary molar and premolars, and mesiobuccal cusps of the mandibular molars and premolars. Nether the PAR Index nor the Deflection Index shows statistical difference in alignment section, only the ABOI which measures alignment of posterior teeth showed statistical difference and this makes a difference between orthodontic specialists and non-orthodontists.

Table 9 shows that 17% ($n = 12$) of non-orthodontist cases scored less than 20 and should pass the model portion of American Board of Orthodontic Phase III examination. Importantly, 32% of orthodontist's cases scored less than 20. However, scores both root angulations, so the actual number of the people who are likely to pass the ABO from this group is slightly lower than these numbers.

Q-sort

Only one of the nine orthodontists detected a difference in outcome of orthodontic treatment provided by orthodontic specialists and non-orthodontists. Only 100 samples selected from the 196 samples using a table of random numbers were tested using the Q-sort index. When we tested these 100 samples using ABOI we found different results from the 196 samples tested by ABOI. In the 100 samples there was no statistical difference in the scores of ABOI between orthodontic specialists and non-orthodontic specialists.

There were statistical significant correlations among these four indices (Table 19), Q-sort with the ABO Objective Grading System had the strongest association (r = 0.58) among the other correlation analysis on Q-sort with the other three indices, which shows the ABO is the closest to the orthodontists' subjective evaluation. The ABO was invented to imitate the examiner's eye.

We focused on whether the PAR Index is good enough to differentiate the sensitive orthodontic outcome treated by non-orthodontists and orthodontic specialists and, finally come to a conclusion that the PAR could not detect the difference, but only the ABO objective grading system detected the differences. Is the PAR Index really not good enough to detect the difference? The PAR Index can certainly show the difference between good cases and bad cases. However, the fact is that PAR Index cannot show the difference between the case treated by orthodontic specialists and non-specialists in this study and previous study.

In the orthodontic graduate clinic at Case Western Reserve University the average post-PAR score is 8.01. The resident in orthodontic program are focused on

perfect finishing. Residents are supervised and spend more time for each appointment than private practitioners. On the other hand, private practitioners also need to worry about how soon they can finish the case. From the patient's point of view, most of them do not care if the PAR scores, as long as the front teeth look good. As long as teeth are straight and no pathology, they want to get out of braces. It is uncommon that one would keep the braces extra six months to achieve PAR score decrease from 2 to 0. Clinical practice is a compromise between time and perfection. What you can do for patients and what you should do for the patients are different but the complained point for the both orthodontic specialists and no specialists might be small.

Our result showed that orthodontic specialists can align posterior teeth better. Unfortunately the majority of the cases from this sample did not achieve the quality the ABO requires to pass phase III of the exam. Although passing the ABO examination is one way to show the orthodontic specialists' superiority, only 23% of orthodontists are board certified (2001).

Today, a successful orthodontic practice seems to have more to do with business than with orthodontic technique or professional ethics. Many orthodontic continue education courses are focuses on practice management. For example, the number of patient seen per day, patient contact time and finishing cases as soon as possible. Patient's management experts say this as long as front teeth are straight, the cases is finish! The patient can probably not tell the difference between a PAR score of eight out of eleven. Patients will see orthodontists who have more people skills

and more video games in the waiting area rather than an orthodontist whose average PAR score is eight. The motivation for orthodontists to provide high quality is internal. Confucius said, " The superior man seeks what is right; the inferior one, what is profitable."

Limitations

There was less distortion of study casts of patients who were treated by non-specialists. Part of this reason was that at the end of the sample collection, it was decided to only take the impressions from students who had been treated by non-orthodontic specialists. The technique for taking the impressions improved by this time, and most of the impressions came out well.

One-hundred dental casts were selected from 196 dental casts using a table of random numbers for Q-sort. One hundred Q-sort samples did not show the difference between specialists and non-specialists in the t-test, although the 196 dental casts for the ABOI show the difference in the t-test. Therefore, the 100 samples and 196 sample used in Q-sort was measured using the ABOI and there was no difference between the specialists and non-specialists. The likely reason for the difference in results for 100 versus the 196 could be that, 1) the 100 cases were not representative 2) a few orthodontists in the 196 cases may have been excellent in the alignment of teeth thus surrey introduce large variation in the data, which the variation for the 100 samples (both specialists and non-specialists had equal variation, the 196 samples had more variation between the specialists and non-specialists), and 3) the differences are so small that larger samples are needed to.

Although the use of occlusal indices is a quick, valid, and accurate method of assessing the dentocclusal aspects of orthodontic treatment results, there are admittedly some limitations. Importantly, changes in facial profile, or cephalometric parameters that reflect the skeletal component of malocclusion are not considered in the quantitative evaluation. Unfortunately, measurement of these variables by valid and reliable methods has not been achieved for the following reasons. First, individual biologic variation requires discrimination between changes attributable to orthodontic intervention and those due to the growth and development of the facial complex. Second, the ideal cephalometric analysis or cephalometric goals of orthodontic treatment are controversial with no consensus throughout the profession. Finally, no universally accepted methods currently exist to assess change in facial profile as an outcome measure. The occlusal index in the present study does not measure other adverse dental conditions such as gingival recession, gingival hyperplasia, enamel decalcifications, dental caries, dental anomalies, or TMD symptoms. The occlusal index may not be sensitive enough to measure the fine detailing that occurs during the finishing stage of orthodontic cases. Although for the time being, the optimal feasible method for assessing the attainment of desired occlusal outcomes is by the use of occlusal indices.

When scoring models in this study, it was necessary to hand articulate them to a "best fit" since there was no wax bite available for this study. Therefore, potential for erroneous results was increased and score would likely higher.

SUMMARY AND CONCLUSION

The present study used the PAR Index, the Deflection Index, and the ABO Objective grading system to compare orthodontic treatment outcome between 196 patients treated by orthodontists and 70 patients treated by non-orthodontists. A subset of 100, 50 dental casts treated by specialists and 50 dental casts treated by non-specialists, were randomly selected from 196 casts and evaluated using a Q-sort technique. All casts were obtained in 1997 and 1998 from 1,047 tenth grade students attending high school in Cuyahoga County as part of a larger study funded by the American Association of Orthodontists Foundation.

T-tests were performed on continuous variable and chi square for categorical variables. A p-value of 0.05 was used to assign statistical significance. The results of the present study showed the following:

1. There was no significant difference between patients treated by orthodontic specialists and non-orthodontic specialists in mean post treatment PAR score.

2. There was no significant difference between patients treated by orthodontic specialists and non-orthodontic specialists in mean post treatment Deflection Index scores.

3. There was no significant difference between patients treated by orthodontic specialists and non-orthodontic specialists in mean post treatment Q-sort scores.

4. There was significant difference between patients treated by orthodontic specialists and non-orthodontic specialists in mean post treatment ABO objective grading system scores ($p \leq 0.04$).

5. There was a highly significant difference between patients treated by orthodontic specialists and non-orthodontic specialists for the alignment section of the ABO objective grading system ($P \leq 0.0007$).

6. These four indices were correlated. However each Index measured different occlusal characteristics with slightly different objectives.

In conclusion, the difference in occlusal outcomes between orthodontic specialists and non-orthodontic specialists is in the fit of the posterior teeth, especially the first and second molars.

APPENDIX 1. IRB APPROVAL

CASE WESTERN RESERVE UNIVERSITY
REVIEW COMMITTEE FOR HUMAN STUDIES
NOTICE OF APPROVAL

TO: Hans, Mark G.

Dept/School: Dentistry

Subject: Notice of (X) Review and approval
( ) Exemption

The committee has reviewed and approved your proposal entitled:
Effect of Provider Education on Orthodonic Outcome

Please be advised that with respect to: (1) the rights and welfare of the individual(s) involved, (2) the appropriateness of the methods to be used to secure informed consent, and (3) the risks and potential benefits of the investigation, the Committee considers your project:

( ) Exempt
(X) Fully acceptable
( ) Acceptable with reservations noted
( ) Not acceptable for reasons noted

Follow-up: The Committee wishes to have a status report on this project on 1/21/2000

SIGNED FOR THE COMMITTEE BY:

Approval Date:
2/04/1999

Christian L. LaMantia
Associate Director
Office of Research Administration

CZ

ORA USE ONLY**********

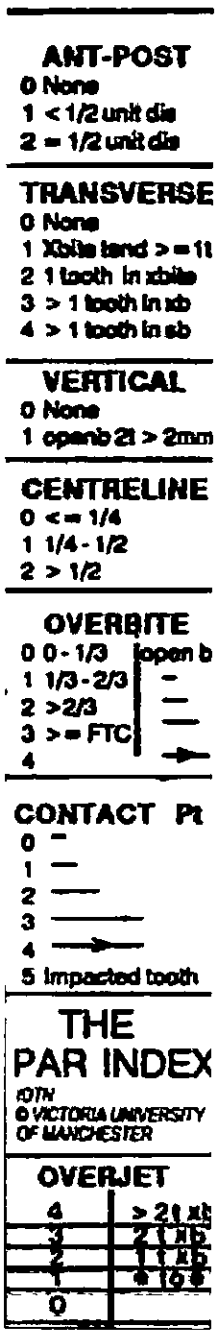
Type Project: ( ) NEW (X) RENEWAL
Human Risk: ( ) Yes (X) No
Source of Support:(X) Outside Funding ( ) Department/other
Agency (Potential): Amer Assn of Orthodo Agency No.

Are any of the following involved: (X) Yes ( ) No
If yes, which category(ies):

(X) Minors () Fetuses () Abortuses () Pregnant Women
() Prisoners () Mentally Retarded () Mentally Disabled

cc: Dean
Department Chairman
Follow-up (Book)
File

APPENDIX 2. The PAR ruler



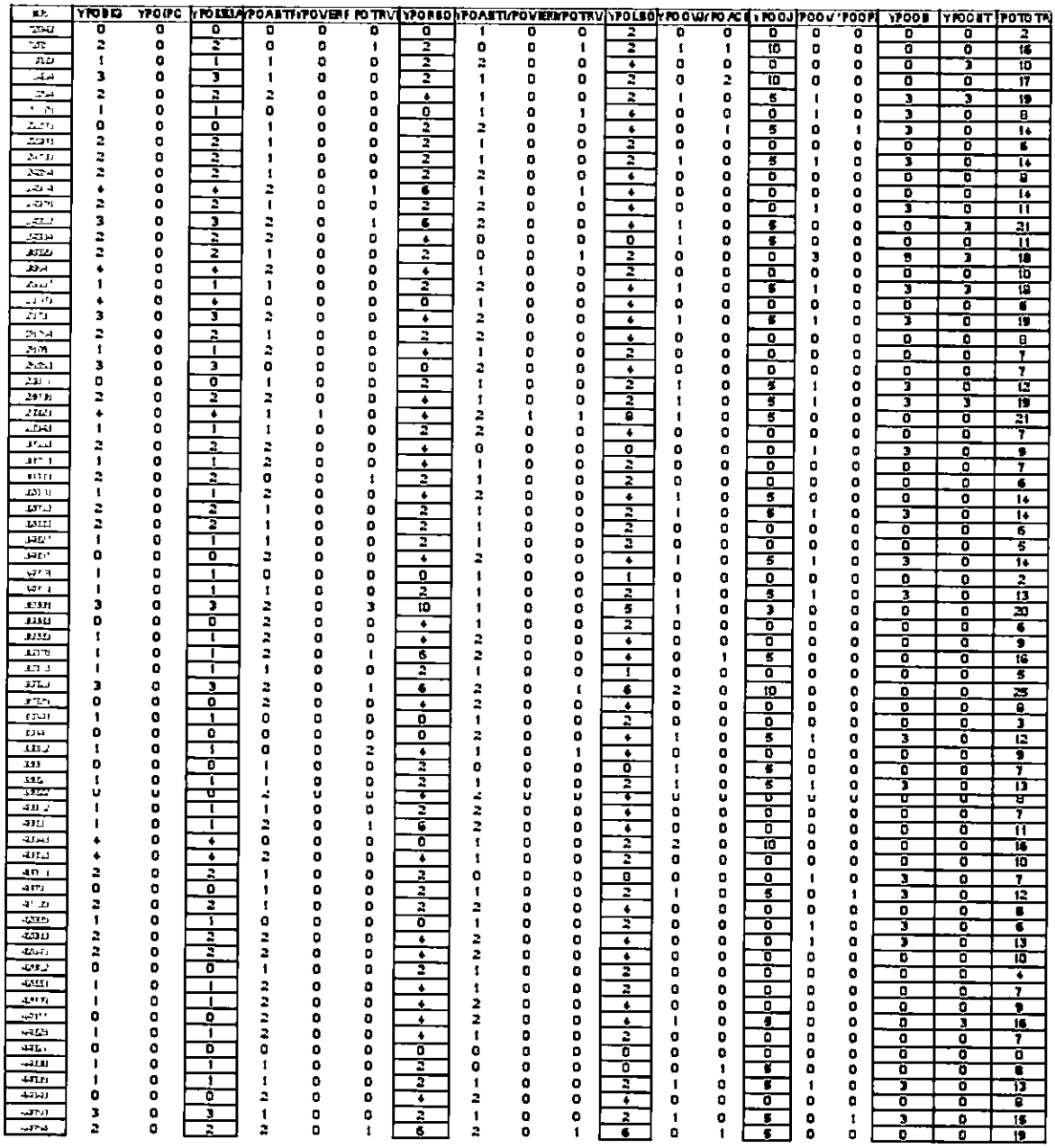
APPENDIX 3. The PAR Scoring sheet

PEER ASSESSMENT RATING INDEX SCORING SHEET

Patient _____ **Rater** _____ **Date** _____

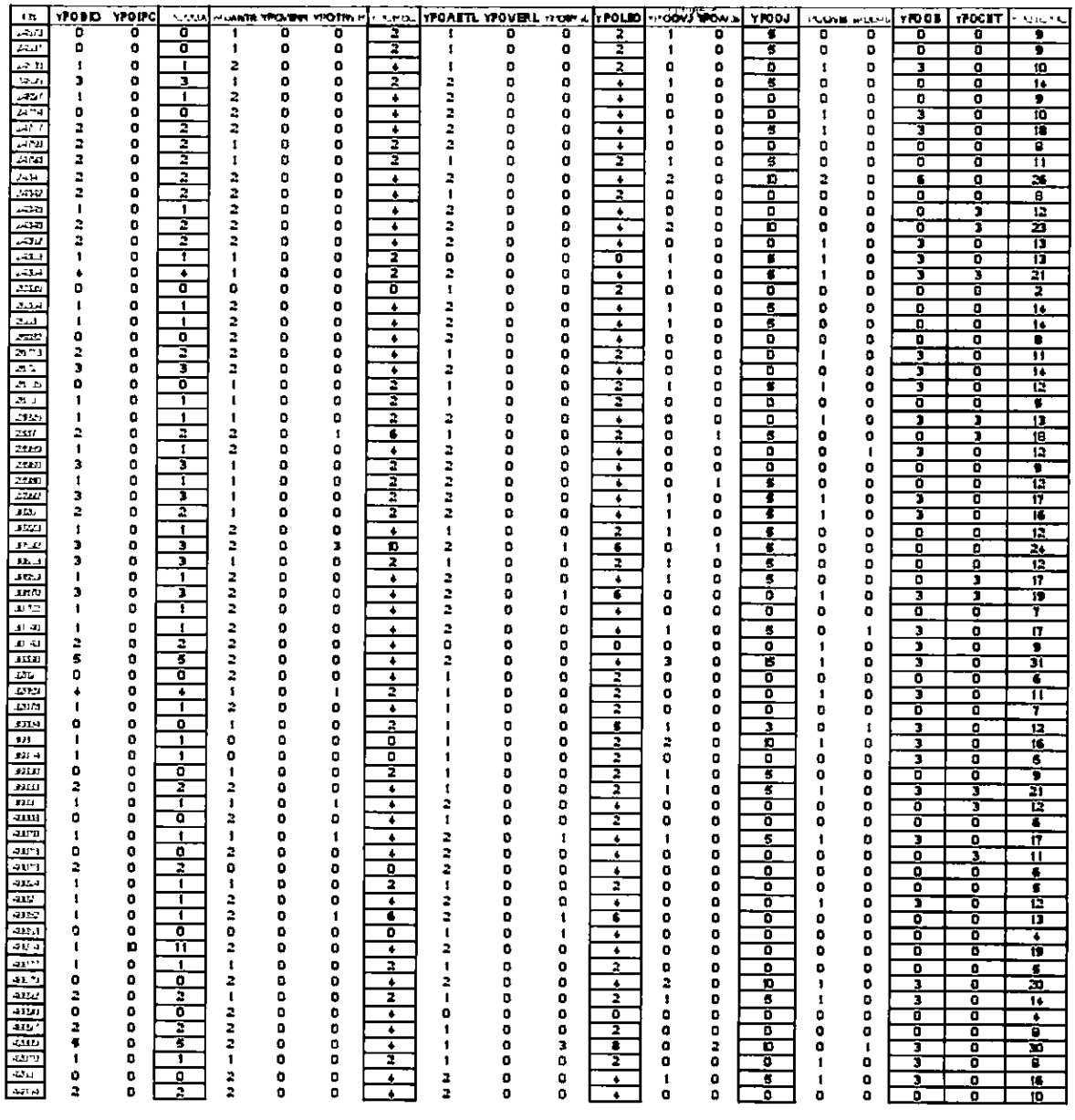
PAR INDEX COMPONENT	SUB COMPONENTS	RAW PAR SCORE	WEIGHTING	WEIGHTED PAR SCORE
Maxillary Anterior Alignment	Displacement			
	Impaction			
	Total		x1	
Right Buccal Occlusion	A-P			
	Vertical			
	Transverse			
	Total		x2	
Left Buccal Occlusion	A-P			
	Vertical			
	Transverse			
	Total		x2	
Overjet	Overjet			
	Anterior Crossbite			
	Total		x5	
Overbite	Overbite			
	Openbite			
	Total		x3	
Centerline	Total		x3	
Totall score				

Appendix 4. The PAR Database for non-orthodontists



APPENDIX 5. The PAR Database for orthodontic specialists

	YPOBID	YPOIPC						YPOAETL	YPOVERL		YPOLBD			YPOOJ			YPOOB	YPOCBT	
	2	0	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	6
	1	0	1	2	0	0	4	2	0	0	4	1	0	5	0	0	0	0	17
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	12
	2	0	2	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	11
	0	0	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	10
	1	0	1	1	0	0	2	2	0	0	4	0	1	5	1	0	3	0	15
	2	0	2	2	0	0	4	2	0	0	4	0	0	0	2	0	6	0	16
	2	0	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4
	1	0	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	7
	2	0	2	2	0	1	6	2	0	2	4	0	0	0	0	0	0	0	12
	1	0	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	11
	1	0	1	1	0	0	1	2	0	0	4	0	1	5	0	0	0	0	11
	0	0	0	2	0	0	4	1	0	0	2	0	0	0	0	1	3	0	9
	0	0	0	2	0	1	6	1	0	0	2	0	0	0	0	0	0	0	8
	1	0	1	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	10
	1	5	6	2	0	1	6	1	0	0	2	0	1	5	0	0	0	0	19
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	12
	2	0	2	2	0	0	4	2	0	0	4	0	0	0	0	2	6	3	19
	0	0	0	2	0	0	2	2	0	0	4	0	0	0	0	0	0	0	6
	1	0	1	1	0	0	2	1	0	0	2	1	0	5	0	0	0	0	12
	0	0	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	6
	1	0	1	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	7
	2	0	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	8
	2	0	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	3	21
	0	0	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	4
	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	2
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	9
	0	0	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	6
	0	0	0	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	6
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	9
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	10
	2	0	2	1	0	0	2	2	0	0	4	0	1	5	0	0	0	0	13
	2	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	5
	0	0	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	8
	2	0	2	2	0	0	4	2	0	0	4	0	0		1	0	3	0	13
	0	0	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	4
	1	0	1	2	0	0	4	2	0	0	4	1	0	5	0	0	0	0	14
	1	0	1	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	7
	0	0	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	6
	1	0	1	1	0	0	2	1	0	0	2	1	0	5	0	0	0	0	10
	2	0	2	2	0	1	6	0	0	0	0	0	0	0	0	0	0	0	8
	1	0	1	2	0	0	2	2	0	0	4	0	0	0	0	2	6	0	13
	0	0	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	4
	1	0	1	2	0	0	4	2	0	0	4	1	0	5	0	0	0	0	14
	1	0	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	7
	0	0	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	11
	2	0	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	13
	2	0	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	8
	2	0	2	2	0	0	4	2	0	0	4	1	0	5	0	0	0	0	15
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	10
	4	0	4	2	0	0	4	2	0	0	4	1	0	5	3	0	9	0	26
	4	0	4	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	10
	2	5	7	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	13
	1	0	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	7
	2	0	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	6
	3	0	3	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	9
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	9
	1	0	1	2	0	0	4	2	0	0	4	1	0	5	2	0	6	2	23
	1	0	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	9



APPENDIX 6 The Deflection Index scoring Sheet

The Deflection Index

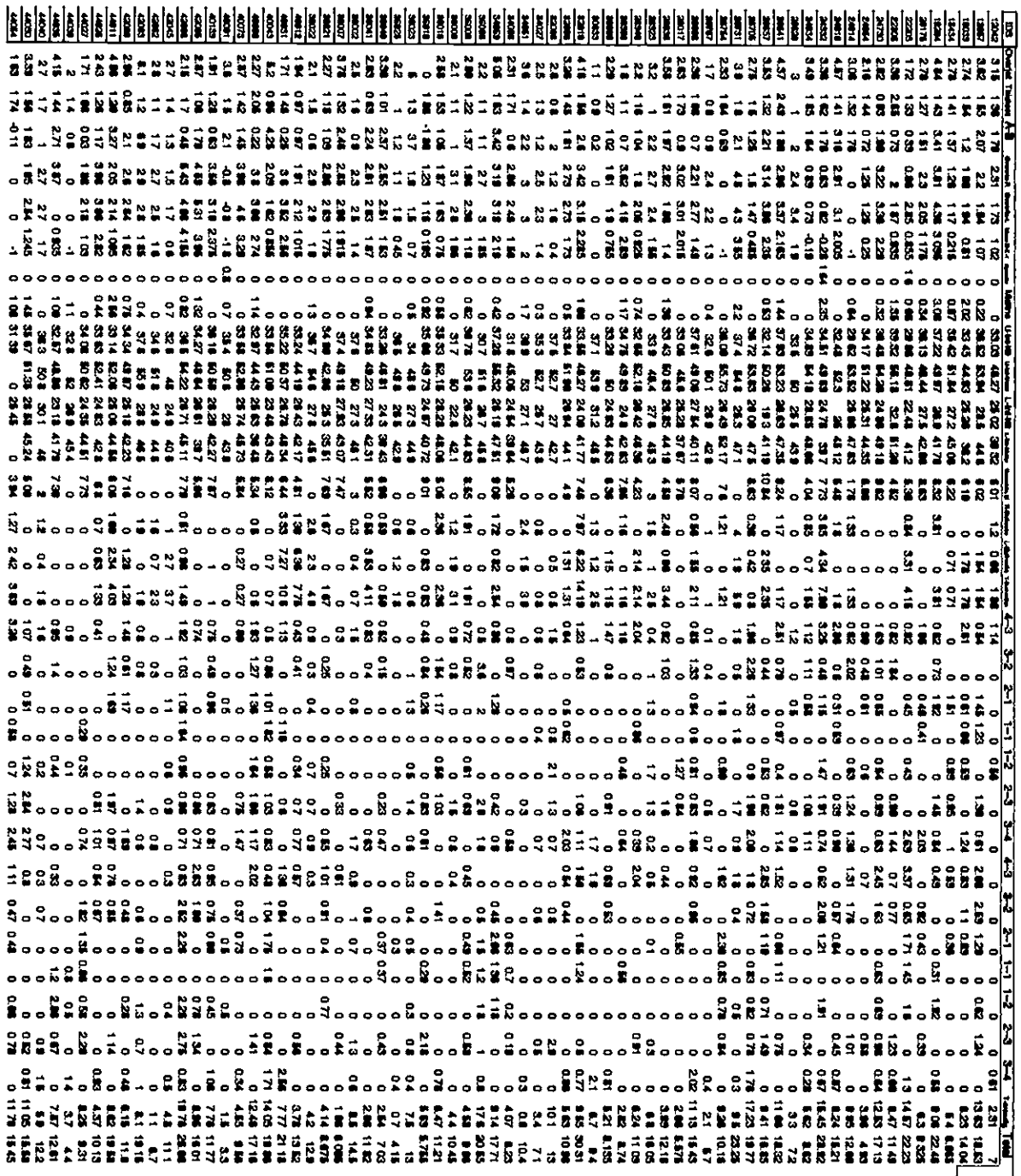
Cast Number _____ Date _____

Examiner Yumi

Overjet	1	Overjet			
	2	Cetral incisor thickess			
	3	1--2	*		
Overbite	4	Overbite		Mean	
	5	4(Mean)--1mm	*		
Openbite	6	Openbite	*		
Midline	7	Midline	*		
Crossbite	8	U-Int-K9			
	9	U-Int Molar			
	10	L-Int-K9			
	11	L-Int Molar			
		10--8			
		11--9			
	12	Crossbite	*		
Deflection	13	Right			
	14	Light			
	20	13+14	*		

Crowding			4--3	3--2	2--1	1--1	1--2	2--3	3--4
	15	Upper							
	16	Lower							
	17	Total-U							
	18	Total-L							
	19	17+18	*						
TOTAL	21	SUM		⇦	Add all*				

APPENDIX 7 The Deflection Index Database for non- orthodontists

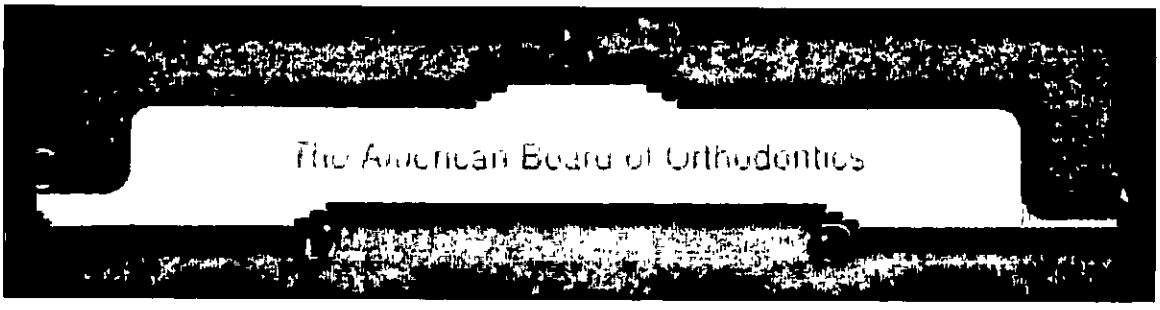


Appendix 8. The Deflection Index Data base for Orthodontic Specialists

ID#	Overjet	Thickness	A-B	Z...	Overbite-R	Overbite...	Mean S-E-I Quarter	Midline	U-bit-Rt	Upper...	L-bit-Rt	Lower...	Overbite	Molar...	Occlusion	4–3	3–2	2–1	1–1	1–2	2–3	3–4	4–3	3–2	2–1	1–1	1–2	2–3	3–4	Tonsils	Total
14039	2.38	1.44	0.94	2.11	2.35	1.23	0	1.21	35.45	50.7	25.78	42.17	7.69	0.25	2.21	2.48	0	1.01	0	0	0	0	1.44	0	0.74	0.49	0	0.75	0	0.63	8.06	10.9
14024	3.8	2.1	1.7	4.5	3.8	3.15	0	0.2	35.8	54.5	27	45.5	0	1.2	0	1.2	0.9	1.6	0	0	0	0	0.7	1	2.1	0	0.5	0.2	1.1	1.5	9.6	15.85
14027	3.16	1.87	1.29	2.73	2.34	1.535	0	0.86	34.86	44.41	24.82	37.47	7.78	0.79	1.25	2.04	0	0.91	0	0.45	0	1.01	0	0.6	1.63	2.14	0.66	1.17	0	1.97	10.54	16.07
14039	3.82	1.71	2.11	1.32	1.46	0.39	0	1.4	35.43	51.75	27.03	43.69	8.4	0	0	0	2.19	0	1.43	0	1.2	0.82	1.05	1.96	0	0.68	0	0	0.41	1.1	10.82	14.72
14048	2.4	1.7	0.7	3.6	3.1	2.35	0	0	34.1	50.9	30.6	42.7	0	0	1.6	1.6	0	0	0.6	0	0	0	0	0	0	0.4	0	0	0.4	0	0	1.4	8.05
14064	3.66	1.62	2.16	2.66	3.65	2.206	0	0	37.05	55.74	29.69	48.16	5.38	0	0.47	0.47	0.82	0.82	0	0	0	0	0	0	0	0	0	0	1.65	0	3.29	8.126
14073	0	1.65	-1.65	5.66	4.41	4.135	0	0.59	35.97	50.72	25.84	42.21	8.13	2.46	1.56	4.02	1.03	0.4	0	0	0	0.78	1.12	0	0.63	0	0	0	0	1.12	5.28	12.38
19099	2.8	1.8	1	2.2	2.5	1.35	0	0	35.1	51.1	25.6	44.8	0	0.8	0.7	1.6	0.8	0	0.6	1.1	0.6	0	0.3	0.4	0	0	0.3	0.2	0	0.4	4.7	8.65
20081	3.7	1.29	2.41	1.34	1.4	0.37	0	0	37.29	53.41	28.71	47.15	6.58	0.96	0.85	1.51	0.54	0.74	1.08	0	0	0	0	0.39	2.16	0	0	0	1.16	0.78	6.85	11.14
20166	3	1.4	1.6	2.7	3.2	1.95	0	0	35.2	47.5	27.3	44.4	0	0.3	0	0.3	1.1	0.9	0.5	0.3	0.7	1.2	0.7	0	0	0.4	0	0.7	0	0	6.5	10.35
20128	2.3	1.4	0.9	0.7	0.3	-0.5	0	1	35.4	52.2	27	44.9	2	1.6	1.6	3.2	1.4	0.9	0.2	0	0	2.1	1.4	1	0	0	0	0	1.9	0.9	15.5
20182	2.15	1.12	1.03	1.75	1.85	0.7	0	0.88	39.13	52.36	31.41	45.5	5.72	0	0	0	1.26	0	1.24	0	0.78	1.26	1.23	1.07	0	0	0	0.61	0.6	0.87	8.82	11.53
20136	1.9	1	0.9	1	0.5	-0.25	0	0	33.5	49.2	26.1	43.9	0	0.5	0	0.5	0.5	0.8	0	0	0	0.6	0.5	0.5	0	0.2	0	0	0	0	3.2	4.35
20187	3	1	2	2.4	2.5	1.45	0	0	32.9	49.8	27.1	42.7	0	0.5	0.7	1.2	0.6	0.5	0	0	0	0.5	0.6	1.3	0.4	0	0.4	0	0	0	4.3	8.96
20188	1.74	1.33	0.41	0.61	0.86	-0.265	0	0	32.94	46.84	24.53	39.84	6.41	0	1.59	1.59	0.94	1.03	0	0	0.46	0	0.47	0.51	0.4	0.34	0	0	0.6	0.96	5.41	7.145
20144	2.97	1.4	1.57	0.85	0.44	-0.355	0	1.16	0	47.26	0	44.31	-2	0.87	0.67	1.54	0	0.62	0.73	0	0	0	0	1.04	0.77	0	1.13	0	0.87	0	5.16	9.075
20188	2	1	1	2.8	2.3	1.55	0	0.8	36.1	54	28.5	46.5	0	1.3	0	1.3	0.7	0.8	0	0	0	0	0.9	0	0	0	0.7	0	0	0	3.2	7.85
20226	2.12	1.44	0.68	1.28	1.7	0.49	0	1.16	33.96	49.5	26.5	43.37	5.16	0	1.71	1.71	1.68	1.1	0.94	0.66	0.64	1.01	0	1.29	0.63	0	0	0	0.48	8.43	12.47
20227	2.51	1.34	1.17	4.05	3.9	2.975	0	2.13	33.33	51.83	24.9	44.35	8.43	3.45	0	3.45	1.36	1	0	0	0	0.51	1.11	0.51	0	0	0	0	0.84	5.43	15.16
20249	5.36	1.16	4.2	1.86	1.89	0.875	0	0.9	33.48	49.58	27.22	48.11	4.26	0.81	1.29	2.1	0	0	0	0	0	0	0.51	0.61	0	0	0.62	0	0	0.85	2.89	10.67
20285	1.9	1.1	0.8	1.3	1.4	0.35	0	0.6	37.1	54.2	27.2	46.4	0	0	1.6	1.6	0.5	0	0.5	0	0	0	0	0.7	0	0	0	0	0	0.2	1.9	5.25
20271	2.48	2	0.48	1.34	1.71	0.526	0	0.93	32.47	46.52	25.73	39.9	4.74	0.53	0	0.53	1.6	0.51	0.56	0	0	1.07	0.58	0.96	0.6	0	0.61	0	0	0.51	5.975
20273	2.57	1.47	1.1	1.49	1.6	0.545	0	0	35.53	54.45	26.56	45.39	7.97	1.6	1.1	2.7	1.53	1.03	0	0	0	1.25	1.09	0.85	0	0.54	0	0.32	0	0	6.61	10.96
20287	3.13	1.15	1.98	3.8	4.22	3.01	0	0.96	32	47.1	22.6	38.16	7.4	1.27	0.77	2.04	0.69	1.71	0.96	0.73	0	1.39	2.06	0.82	1.09	0.85	0.6	2.3	0	1.97	15.27	23.16
20315	2.06	1.15	0.91	1.15	0.91	0.045	0	0.91	33.7	48.61	25.58	42.46	6.12	1.06	0.93	2.02	1.23	0.73	0	0	0	0.84	1.11	1.14	0	0	0	0	0.44	0.6	5.89	8.675
20316	1.6	0.8	0.8	2.9	3.4	2.15	0	0.3	35.2	51.1	26.5	45.2	0	0	0	0	0.8	0.7	0	0	0	1.2	0.6	1.6	0.4	0	0	0	0	0.7	5.2	9.45
20324	2	0.7	1.3	1.5	1.6	0.65	0.3	0.8	34.2	53.1	27.6	43.4	0	0.6	0.9	1.5	0.8	1.2	0	0	0.4	0	1.8	0	0.5	0.3	0	0.5	0	0	5.5	9.95
20339	2.3	1.1	2.2	2.2	2.6	1.4	0	0.7	36.4	57.5	28.6	50.1	0	0	0.3	0.3	0.6	0	0	0	0.7	0	0	0	1.3	0	0	0.7	0	1	4.3	8.9
20348	3	1.5	1.5	2.5	2.5	1.5	0	0.7	35.6	53	27.3	47.6	0	2.2	0	2.2	0.4	0.5	0	0	0	0	0	0.7	0.8	0.3	0	0	0	0.8	3.5	9.4
20361	2.4	1	1.4	1.8	1.8	0.65	0	1.2	34.1	53.5	27.4	45.4	1.5	2.7	0	2.7	1.8	1.1	0	0	0	1.5	1.7	0.3	0	0	0	0	0.1	0	6.5	13.95
20363	2.5	1.2	1.3	2.6	2.9	1.75	0	0.6	35.1	50.8	27.3	44.9	0	0	0	0	0	0	0.6	0	0.4	0	0	0.7	0	0	0	0	0	0.6	2.3	5.95
20366	1.5	0.9	0.6	1.1	1.3	0.2	0	1.1	29.8	48	23.4	41.8	0	0	0	0	0	2	0.8	0	0.8	0.6	0	0	0.5	1.9	0.6	0	0	0.8	7.8	9.7
20370	2.6	0.8	1.8	3.8	3.4	2.6	0	0	34.8	49.7	27.5	43	0	0	0	0	0.7	0.4	0.6	0	0	1	0	0.8	0	0	0	0.1	0.6	0.3	4.5	8.8
20375	1.8	0.8	1	1.3	1.8	0.55	0	0.4	37.3	53.7	28.7	44.4	0	3.4	3.4	6.8	1.7	0.5	0.4	0	0	0	1.1	0.6	0.6	0.3	0	0	0.3	0.5	6	14.75
20378	2.66	1.76	0.89	2.86	2.9	1.89	0	0	34.71	52.5	23.75	45.28	8.96	0.4	0.78	1.18	1.5	0.96	0	0	0	0.58	0	0	0	0	0	0	0	0	3.04	7
20380	1.48	1.05	0.43	2.2	2.18	1.19	0	0.68	33.84	50.4	25.54	41.91	6.1	1.18	0.71	1.89	0	0	0	0	0	0	0.46	0	0	0	0	0	0	0	0.46	4.65
20401	4.73	1.7	3.03	2.06	2.01	1.035	0	0	35.97	52.36	27.91	43.84	6.06	0	0	0	0	0.55	0	0	0	1.08	0	0	0	0	0	0	0	0.82	0.86	3.11	7.175
20405	2.3	1.4	0.9	2	2	1	0	0.8	34.6	56.3	26.3	47.4	0	2.3	1.4	3.7	0.4	0.4	0	0	0	0	0.5	0.5	0.6	0	0	0	1	0.9	4.3	10.8
20410	1.6	1	0.6	1.5	1.8	0.75	0	0.7	33.9	47.3	24.8	39.5	0	1.9	2.7	4.6	1.2	2	0	0	0.4	0.6	0.7	1.9	0	0	0	0.3	0	2.4	9.5	16.15
20418	3.2	1	2.2	3.3	3	2.15	0	0	35.1	48.5	28.8	39.5	0	0	0	0	0	1	0	0	0	0	0	0	0.7	0.7	0	0	0	2.4	6.75
20435	3.4	1.86	1.52	0.8	0.078	-0.561	0	0	32.45	50.72	26.97	44.79	3.46	0	0	0	1.61	0	0	0	0.51	0.84	0	0.75	1.24	0.62	0	0	0.75	0.75	6.67	7.629
20437	3.8	0.8	2.7	0	0	-1	2.6	0	32.9	52.4	26.6	46.9	0	0	1	1	0	0	0	0	0	0.9	0	0	0	0	0.8	0.4	0	0	2.2	7.5
20439	2.29	1.75	0.54	1.17	1.3	0.235	0	1	36.26	48.15	27.8	40.7	6.45	0.5	0	0.5	0.59	0	0	0	0	0	0.58	0	0	0	0	0	0	0.44	1.71	3.935
20465	2.2	1.7	0.5	1.4	1.3	0.35	0	0	35.3	54.8	27	48.1	0	3.5	0	3.5	0.4	0	0	0	1	0	0	1.5	0	0.4	0	0	0.5	0	3.8	8.15
20481	2.2	1.1	1.1	1.4	1.6	0.5	0	0	34.3	44.6	26	36.8	0	0	0	0	1.3	0	0	0	1.3	0	0	0.6	0.8	0	0	0.4	0	0.5	4.9	8.5
20478	1.9	1.3	0.6	2.3	2.4	1.35	0	1.6	32.6	47.6	26	41.1	0	3.9	0.5	4.4	0	0	0	0	0.2	0	0	0	0.5	0	0	0	0	0.7	6.65
20485	3.2	1.3	1.9	3	3.1	2.05	0	0	35.2	53.6	28.6	45.2	0	0	0.2	0.2	0	1.5	0	0	0.5	1	0.9	0.9	0	0	0	0	0	0.7	5.5	9.65
20488	2.45	1.45	1	1.94	2.03	0.986	0	0.76	29.98	47.35	24.42	39.29	3.57	0	0	0	1.57	0.63	0	0	0	0	1.28	0	0	0	0	0	1.73	0	5.21	7.855
20500	3.36	1.68	1.7	2.58	2.52	1.55	0	0	37.15	53.77	27.48	47.78	7.66	1.56	1.03	2.59	0.95	0.9	0	0	0	2.1	1.4	0	0.36	0.48	0	0	0.35	0	6.54	12.36
20502	2.7	1	1.7	4.1	3.1	2.6	0	0	34.5	50.5	27	42.9	0	1.1	0	1.1	0	0.6	0	0	0	0.8	0	0	0	0	0	0	0	2.3	3.7	9.1
20504	4	1.2	2.8	4.1	4.1	3.1	0	0	32	48.8	23.3	41	0	0.4	1.5	1.9	2.7	1.6	2	1.2	0.5	0.8	0.6	3.2	0	0	0.8	0.6	4.5	1.3	19.8	27.6
20526	4.1	1.7	2.4	2.3	2.3	1.3	0	0	34.1	47.4	26.2	43.5	0	0	0	0	0.7	1.5	0.5	0	1	1	1.6	0	0.6	0	0	0	0.6	0	7.5	11.2
22167	3.51	1.2	2.31	1.87	1.67	0.77	0	0.36	33.01	49.33	25.65	43.28	5.36	0	0	0	2.1	0.83	0.51	0	0.45	0.67	0	0	0.49	0.49	0	0.57	0	0	8.11	9.57
22218	2	1	1	2.1	2.6	1.35	0	0.3	39.1	50.7	28.6	48.6	2.3	0.3	0.2	0.5	0.5	0.5	0	0	0	0	0	0	0.6	0	0	0	0.6	2.2	7.65
22625	3.4	1.91	1.49	2.67	2.86	1.785	0	0	37.03	54.18	29.09	47.35	5.94	0	0	0	0	0.61	0	0	0	1.1	0	0	0.77	0	0	0	1.1	0	3.58	6.835
24193	1.9	1.2	0.7	2	1.8	0.9	0	0.8	37	53	26.3	44	0	0.3	2.7	3	1	0.5	0	0	0	0.8	0.5	0	0.5	0	0	0	0	0	3.3	8.7
24463	2.2	1	1.2	1.2	1.2	0.2	0	0.4	36.6	50.2	27.9	43.2	0	0.3	0.6	0.9	0	0	0.5	0	0	1.3	0	0	0	0	0	0	0.6	0	2.4	5.1
24545	3.1	0.9	2.2	2.7	2.8	1.75	0	0.8	35.2	52.1	21.6	45.3	0	0.4	0.9	1.3	0	0.7	0.3	0	0	0	0	0	0.4	0	0	0	1	1.8	4.3	10.35
24547	0	0.6	-0.6	2.3	2.1	1.2	0	0.3	36.9	55.2	28.6	43.9	0	2.3	4	6.3	1.5	0.8	0	0	0	0	0	0	0	0	0.2	0	0.6	0	3.1	10.3
24573	3.44	2.06	0.78	0.4	0.68	-0.46	0	0	32.84	43.63	24.06	37.9	6.78	0	0.89	0.89	0.74	0.86	0	0	0.91	1.34	0	0	0	0	0	0	0.59	0.42	4.76	8.07
24581	2.8	1.81	0.89	0.71	0.7	-0.285	0	0.46	32.96	49.87	24.37	42.86	5.89	0.33	0	0.33	0.85	0	0	0.65	0	0.52	0.42	0.58	0	0	0	0	0.57	0.41	3.8	5.185
24886	1.3	0.9	0.4	2.1	2	1.06	0	0.6	32.5	50.6	23.6	42.7	0	0.8	0	0.8	0.5	0	0	0	0.5	0	0.7	0	0	0.9	0	0	0	0.3	2.9	5.75

ID3	Overjet	Thickness	A-B		Overbite-R	Overbite-L	Bite-R-1	Bite-L-1	Midline	U-Int-R	U-Int-Ht	U-Int-L	L-Int-R	L-Int-Ht	L-Int-L	Crowding-R	Crowding-L	4–3	3–2	2–1	1–1	1–2	2–3	3–4	4–5	5–2	2–1	1–1	1–2	2–3	3–4	Crowding	Total
24696	3	1 1	1.8	1 4	1 1	0.25	0	0	35.5	49 1	28	41 7	0	0	1 1	1 1	0 1	0	1.2	0	0.8	0	0.8	1	0 5	0.5	0 1	0.4	0 5	1 1	7	10.25
24697	1.9	1.2	0 7	1.5	1 6	0.55	0	0.6	36.4	48	27.5	40.2	0	0	0.9	0.9	0	0	0	0	0	0	0.7	0	0	0.2	0	0	0	0 7	1 6	4.35
24714	2.25	1.33	0.83	3.15	3.06	2.105	0	0	32.19	49 49	24.99	41.99	5 18	0	1	1	0.81	0 6	0	0	0	0.38	1 7	2.02	0.72	0	0	0.25	0	2.45	9 03	13 07
24717	3	1 4	1 8	3 1	3.5	2 3	0	0.3	33.4	45.9	23.5	40.5	0	0.8	0	0.9	0.3	1.2	0.9	0	0	0	1	0	3.2	0.7	0 5	0	0.9	1.2	9.9	15
24799	1.58	1 17	0.41	1 47	1 41	0.44	0	0	30.82	45.87	23.42	37.86	5 4	0	0 14	0 14	0 06	0	0	0	0.05	0 43	0.23	0 12	0	0	0	0	0.34	1.27	2.5	3 49
24796	3.4	1	2.4	1.5	1.5	0.55	0	0.6	36.2	49 6	24.9	41 6	0	0	0.8	0.8	1 1	0	0	0.6	0	0	0	0	0.8	0.8	0.3	1 4	0 8	0	5.9	10.45
24841	3 64	1 74	1.9	2.42	2.4	1 41	0	0.36	34 75	52.18	27 66	48.26	5 1	0 81	0 49	1.3	0.59	1.22	0	0	0	1 7	1.23	0.71	0	0.55	0.98	0.48	0	0.59	7 64	12.63
24842	2	1.56	0 44	1 61	1.28	0.435	0	0	32.22	47 18	24.21	41 83	6.01	0	0	0	0.42	0	0 48	0	0.58	1.36	0.52	0.47	0.41	0	0	0	1 06	0.63	5.93	6.805
24845	3.9	1	2.9	3.1	2.5	1.8	0	3.8	33 7	47 6	23	36.5	0	1 4	1.9	3.3	0.8	0	0 6	0	0	0	0	0	0	0	0 4	1.5	0.6	3.9	15.8
24846	5.3	1.3	4	1 7	1 6	0 65	0	1 4	33.5	45.4	23 7	41	3	0 9	0.7	1 6	0 7	1 1	0	0	0	0 5	0	0	0	1 1	0.5	1	0	0.7	5.7	16.35
24862	2.44	1.3	1 14	2.03	2.24	1 135	0	1.58	35.9	48.39	27 02	42.02	6.88	0	0	0	1 02	0.88	0	0	0	0.65	0.8	0.37	0.84	0	0	0.33	0	0	4.57	8.425
24863	3.3	1.3	2	2.6	2.2	1 4	0	0	34.9	51 8	28 1	44 4	0	0	0.7	0 7	0.3	0 5	0	0	0	0	0.5	0.2	0	0	0 6	0	0	1.5	3 6	7 7
24864	4 58	1.21	3.37	3.04	3.21	2.125	0	0	30 79	44 75	25 17	40 14	3 62	0	3 51	3.51	1 16	0 76	0	0 53	0.7	1.31	1 17	1.04	0	0	0	0	0	0.75	7.42	16.43
24639	2	1	1	1 1	1.2	0 15	0	0	32.8	53	34 8	44 9	0	0	0 6	0.6	0 6	0 8	0	0	0	0.9	0.8	0.7	0	0	0	0 4	0	0 7	4.9	9.65
24864	3.5	1	2.5	2.2	2.2	1.2	0	0.8	33	44	25 1	40.3	0	0	0	0	1 8	0	0	0	0	0.5	1	0.7	0.3	0	0	0	0	0.4	4 7	8.2
24881	3 7	1 7	2	3.1	3.7	2.4	0	0	40.9	56 7	30 5	48 1	0	0.8	0.8	1 7	1.5	0	0	0	0	2.5	2.5	1 4	0	1 5	1 1	0 4	0	1 4	12.3	18.4
24882	2.55	1 54	1 01	3 41	3 4	2.405	0	0.82	34 84	48.62	28.39	39 99	4.25	0 66	1 84	2.3	0.95	0	0	0	0	0	0.95	0.78	0	0	0	0	0	0.8	3.29	9.825
25718	3	1.2	1 8	4.2	2 5	2.35	0	0 4	32.3	48.6	26.7	42.6	0	1 6	0	1 6	0.7	1	0 1	0	0	0	0.4	0	0	0	0	0	0	0.4	0.4	3	9 15
26781	1.37	1.22	0 15	2.69	2.87	1 68	0	0	34.89	50.29	25 04	45 44	7 55	0 92	0 6	1 42	0 6	1.25	0 45	0	0	1 28	0	0	0	0	0	0	0 76	1.36	5.73	8.96
26785	3.7	1 6	2.1	2.8	2.1	1 45	0	0.5	34 1	52.1	26.5	44 7	0	0 6	1	1 6	1 5	0	0	0	0	0	1.5	0	1.2	1 5	0	1	0.7	0	7 4	13.05
26737	1 6	1 6	0	2.1	2	1 05	0	0	37 1	56.6	27.9	49 7	0	0	0 9	0 8	0	0	0	0	0	0	0.8	1.9	0	0	0	0 4	0	0.8	3.8	5.75
26825	2.75	2 04	0.74	2.38	2.62	1 5	0	0.25	33.28	47 69	26.3	41 8	5 98	3 4	2.67	6.07	1.39	1.76	0	0 5	0	0	0	3.1	2.67	1 42	0	0	0	0.78	11 62	20.18
26871	0	1	-1	0	0	-1	0	2.5	34 4	50 7	28.2	43 8	0	5.3	0	5.3	3	1.3	0 7	0	0 5	0.9	1 7	0.4	0	0	0	0.2	0.3	0	9	14 9
26888	0.5	1 74	-0.84	0	0	-1	0	0.66	33.28	53 14	28 61	47 81	4 68	1.3	2.83	4.23	0.83	0	0	0	0	0	1.38	0	0.76	0	0	0	0	0	2.98	6.04
26889	2.47	1 47	1	2.11	1.37	0.74	0	0 53	32 45	48.81	24 61	42.16	5 84	0	1.23	1.23	0 78	0	0 57	0	0 63	0	0	0	0	0	0	0	0 49	0	2.51	6.01
26890	0	0.96	-0 96	0	0	-1	0	0 66	36.56	55.36	29 47	47 52	5 08	0	0	0	0	0 55	0 28	0	0	0	0 54	0	0	0	0	0	0 42	0	1 82	0.52
26902	3.7	2.1	1 6	2.6	2.4	1.5	0	0 4	32.8	49 6	25 7	43 4	0	0 3	0	0.3	0.3	0 6	0 6	0	0 7	0	1	0	0.3	0 4	0	0.3	0	0.3	4 7	8.5
26291	3 7	0.8	2.9	1.4	1 7	0 55	0	0	34.8	52.3	26.2	45.2	0	0	0.2	0.2	0.3	1 6	0	0	0	1.2	0 9	0.6	0	0	0	0	0.2	0	4.8	8.45
26229	3 78	1.2	2.58	2.57	2.56	1.565	0	0	33.47	44 64	23 82	37.22	7 65	0	0 96	0.96	0.46	0	1.26	0	0	0	0	0 51	0.48	0.44	0.36	0	0.46	0.87	4.86	9.965
26592	3 55	1.25	2.5	0 7	1 11	-0 095	0 87	1 09	34.21	48.84	27.25	42.69	4 96	2.75	5.52	8.87	1.67	0 5	0.95	0	0	1 56	2.05	0.85	0	0	0	0.22	0 66	0	8.48	21 62
26863	2.54	1 4	1 14	2.02	2.02	1 02	0	0.73	30.86	49 11	23 63	42.41	5.23	0 54	0 83	1.37	0	1.35	0	0	0 55	0 85	0	3.03	0.6	0	0	0	0.76	0.93	8.07	12.33
26869	1 16	0	1 16	1 14	0.79	-0 035	0	1.23	34 5	52.12	26.17	42.36	6.33	0 96	0 82	1 77	1 16	0	0	0	0	0	1 13	0.93	0	0.42	0	0	0	0	3.64	7 765
26870	3.3	1	2.3	2.4	2.8	1 6	0	1.2	35.2	51 5	28.3	46.3	2	0	2.4	2.4	1 1	0.9	0	0 1	0	2.8	2.3	0	0.3	0.3	0.4	0.6	0.7	0.7	10.2	19 7
26702	2.4	1 1	1.3	1.3	0 8	0 05	0	0	36.9	55 5	30	47 8	0	0 9	0	0.9	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0.6	0	1.2	3.45
26740	3 6	1.3	2 5	-1 1	-0 7	-1 9	1 5	0.5	35 3	54.5	30	48	0	0	0	0	0 4	0	0	0 7	0.5	2.2	1.5	0	0.5	0	0.2	0	0	0.2	6.2	8.8
26746	2.4	1.5	0.9	3.2	3	2 1	0	1 4	36	52.6	28.8	45 6	0	1 6	0	1 6	1 4	0	0	0	0	0 8	0 9	0.5	0	0	0	0	0.8	0	4 4	10 4
26830	8.56	1.25	7.31	3 87	5 16	3 615	0	2.07	34 78	47 98	28.92	42.78	3 86	3 15	4 1	7.26	2.12	0	1 48	1 59	0 97	1 41	1 84	0	1.39	0	0	0 85	0	0	11 76	31.91
26827	1 4	0 7	0 7	1 7	1 5	0 6	0	0	37 7	54.3	27.2	46.1	0	0.3	1 4	1 7	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	4.2
26866	2.91	0 91	2	1 71	1 86	0 765	0	3 73	36.43	52.58	24.3	44 43	10 13	0	1 06	1 06	2.16	1.59	0 78	0.37	0.82	3.63	1.27	1 19	0	0.11	0	0.2	0	0.38	12.79	20.37
26876	2.59	0 86	1 71	1 87	1 57	0 72	0	0	34.34	47 68	26 15	43.33	6.19	1 48	0	1 48	0 4	0.73	0	0	0 09	0.45	0.8	0.53	0	0	0	0	0	0.59	3.59	7.5
26004	3 6	1.2	2.4	2.3	2	1 15	0	0	35.9	51 6	26.3	43 8	0	0	0	0	1.1	1 1	0 1	0 4	0	0.4	0 5	1.3	1.2	0	0	0 7	0 8	0.5	8.1	11 95
26867	4 5	1 1	3 7	2.2	2 6	1 4	0	0	34 5	53.2	26.8	43.9	0	0	0	0	0	1 7	0	0.2	0	0	1.3	1.5	2.1	0	0	0	1	0 7	8.3	13.4
26814	2.8	1.2	1 6	3 1	2.4	1 76	0	0 6	34 4	50.9	26.9	46 1	0	0	0	0	1.6	0	0	0	0	0.8	0.9	0	0	0.9	0	0	0	0	4 1	8.05
26880	2.3	1.2	1 1	3	2 6	1 8	0	0 6	31.7	46.7	23 5	40.3	0	1.5	0	1.5	0 7	0.2	0 5	0	0	0	0	0	0	0	0 8	0	0	0	2.2	7.2
26833	3	1.2	1 8	3.3	3 5	2 4	0	2 4	39	48.6	28.3	39 4	0	0	0.2	0.2	1	0	1 4	0	0	2.3	4 5	0	1 1	0 7	0.3	0.8	1.2	0	13.4	20.2
26837	1 8	1.2	0 8	2.1	1 8	0 95	0	1 7	34.8	48.1	26.21	41 6	0	0	3 6	3 6	0.7	0 8	0 8	1	1.3	0	0	0	0	0 5	1 1	0.3	0	0	6.8	13.45
40866	3.01	1 69	1.32	0	0	-1	0	2.27	34 66	52.51	26.44	46 83	6.22	0 73	0 43	1 16	0.53	0	0	0	0	0	0	0	0 6	0	0	0	0 86	0	1.98	5 74
40818	4.2	1.3	2.9	3 6	3	2.3	0	0 5	35.2	50.6	27.2	45 6	0	0	0	0	1.5	0	0	0	0	0	1.8	1.2	1.8	1 1	0.2	0	1 7	0 6	10	15.7
40818	1.5	0 5	1	1 4	1.2	0.3	0	1.2	32.7	54.2	26	43 5	0	1 4	2.8	4	0	0	0	0	0	0 2	0	0	0	0	0	0	1	1.2	7 7
40018	2.2	1 1	1 1	1.5	1 6	0.55	0	0	34	50 9	27 7	45 5	0	0	0.3	0	1 6	1 5	0	0	0 6	0.8	0	0.8	0	0	0	0	0.5	0.8	6.8	8.45
40824	1 1	1 1	0	0.8	0 8	-0 15	0	0.3	32.3	47 5	22.8	40 6	0	0 8	0	0	0.3	0	0	0	0	0.8	0	0	0.2	0	0	0 4	0	1 7	1.85	2
40827	2.6	1 47	1 13	1 79	2.05	0.92	0	0.86	37 75	52.85	28 05	46.13	7 7	2.39	1 41	3.8	0.7	1 04	0 42	0.32	0	0	0.48	0.86	0	0	0	0	0	0	3.92	10.65
40852	2	0.9	1 1	2	2.8	1.3	0	1 1	32.9	49 1	27 6	48 5	0	0 6	1 5	0.8	0	0	0	0	0 6	0.6	0.2	0	0	0	0	0	0.3	2.3	7.3	12.3
40888	3.45	1.35	2.1	2.75	2.74	1 745	0	0.96	36.56	50.83	27 07	46 45	7 49	0	1 63	1 63	0	0	0	0	0	0	0 43	0.65	0	0 39	0.92	0.57	1 04	4	10.44
40874	2.1	1.3	0 8	2.8	2	1 4	0	1 4	24 1	44 1	25 6	44.3	0	3 4	5 8	9.2	3 6	0	0 7	0	0	0 4	2.5	0.6	0	0	0	0	0	0.5	8.3	21 1
40877	2.5	1.3	1.2	0.9	1.3	0 1	0	0 4	32.3	51.9	23.2	43 1	0	0 6	0	0.6	1 4	0	1 1	0	0	0 5	1.5	0.2	0.8	0	1.3	1.3	0	0	8.1	10.4
40079	2.3	1.3	1	1 4	1.2	0.3	0	4	35.9	49	29.3	42.7	0	1.3	1.2	2.5	1.1	0	0	0	0.4	0	0	1	1.2	0	0	0 9	0	0 4 6	12.4
40082	3	0.8	2.2	4 1	3 7	2.9	0	0	36.9	54 5	26.3	45.3	0	0	1.3	1.3	0.9	1 7	0.7	0	0.5	1 4	0.8	0	0	0	0	0 6	0	0.4	7	13.4
40886	3	1.2	1 8	2.3	2.2	1.25	0	0	37	54 5	28.2	46.2	0	1.2	0	1.2	1.3	0	0	0	0	0	0	0	0	0	0	0 4	0	0	1 7	9 85
40887	2.5	0.8	1 8	3 6	3.2	2.4	0	2	33	53	24.2	47 4	0	4.2	0 6	4 8	1.5	0.9	0	0	0	1.2	1 1	0.7	0	0	0	0 4	0.5	0	8.3	17 1
42008	1 8	1 1	0 7	0	-0 4	-1.2	0 4	0.2	35 7	48.4	27.2	43 4	2 5	2.4	0	2.4	1.2	1.9	0	0 9	1	2.4	3.1	0.9	0 8	0	0.4	0	0.4	0	12.8	17 8
42010	3	1 1	1.9	4 7	4 6	3 65	0	0	33.5	48.7	22.7	41 4	0	0	0	0	1	1 1	0.7	0	0.6	0	1 1	0	0.2	0	0.3	0	0	0	5	10.85
42809	4	1 7	2.3	2.8	2.8	1 8	0	0	34.3	47 4	25 1	40 1	0	0	2.4	2.4	0	0	0	0	0	0.5	0	0	0.6	0.6	0	0.8	0	0	2.5	9
44834	2.86	1 96	1.2	0 72	0 7	-0.29	0	0 76	35 05	45 99	26 16	41 62	6.89	8 01	7 5	15 51	0 96	1.35	0 76	0 53	0 82	0 94	0 78	1.99	0	0	0	0	0	0	7 63	24.81

APPENDIX 9. The ABO Objective Grading System ruler



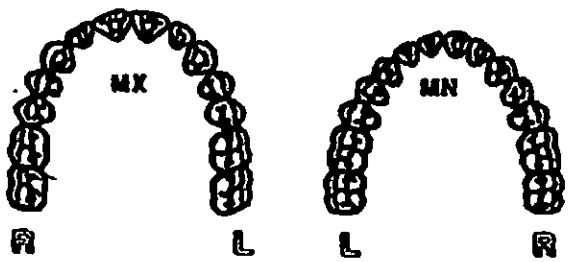
APPENDIX 10. The ABO Objective Grading System

CCRE EVALUATION

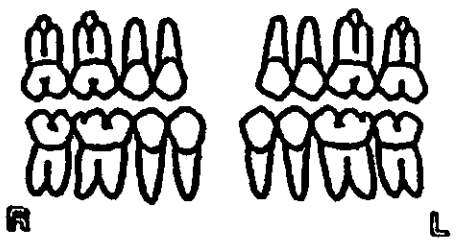
CASE #_____

MODELS_____ _____

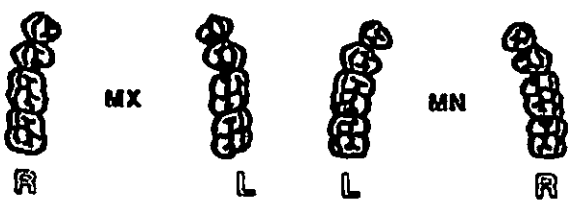
ALIGNMENT



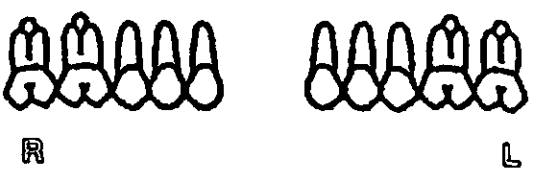
OCCLUSAL CONTACTS



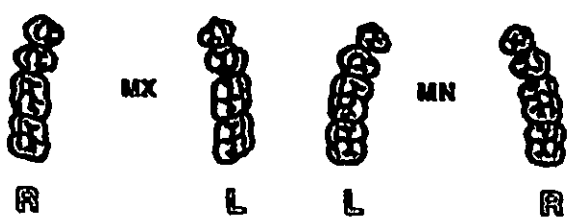
MARGINAL RIDGES



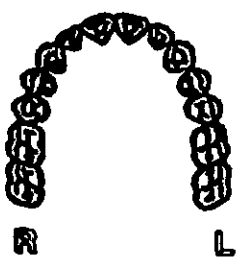
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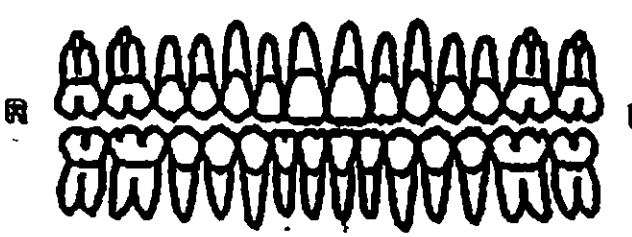
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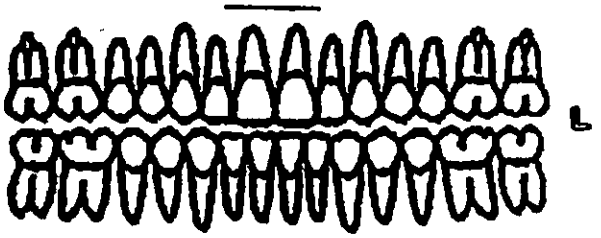
OVERJET



ROOT ANGULATION



INTERPROXIMAL CONTACTS



APPENDIX 11. The ABO Objective Grading System instruction

MODEL GRADING SYSTEM

INTRODUCTION

The American Board of Orthodontics is constantly striving to make the phase III clinical examination a fair, accurate, and meaningful experience for candidates. In an effort to enhance the reliability of the examiners and provide the candidates with a tool to assess the adequacy of their finished orthodontic results, the Board has established an Objective Grading System to evaluate the final dental casts and panoramic radiographs. This scoring system has been developed systematically through a series of four field tests over a period of five years. The Board has instituted the model and radiographic portions of the Objective Grading System, which will be officially used to grade these portions of the candidates' clinical case reports since 1999. In an effort to assist candidates with the selection of their cases, the Board is making this Objective Grading System available to all candidates. The Board encourages candidates to score their own case reports with this scoring system to determine if they meet Board standards.

BACKGROUND

In 1994, The American Board of Orthodontics began investigating methods of making the phase III examination more objective. Since a major emphasis has always been placed on the final occlusion, the first efforts were directed at developing an objective method of evaluating the dental casts and intraoral radiographs.

In the past, several indices have been used to evaluate the outcome of orthodontic treatment.[1,2,3,4] Generally, these indices compare pretreatment and posttreatment records to determine the quality of the final result. However, these indices are not precise, and the validity and reliability of these indices has not been established. The Occlusal Index[5] has also been used to determine treatment quality. However, this method is tedious, and the system is more appropriate for scoring pretreatment rather than posttreatment records.

In 1987, the PAR Index[6] (Peer Assessment Rating) was developed to assess an occlusion at any stage of development. Over 200 dental casts representing various pretreatment and posttreatment stages of occlusion were used to establish this index. The PAR Index has good reliability and validity, however this measuring system is not precise enough to discriminate between the minor inadequacies of tooth position that are found in ABO case reports. Therefore, an ABO committee was formed in 1994, to begin field testing precise methods of objectively evaluating posttreatment dental casts and panoramic radiographs.

At the 1995 ABO phase III examination, 100 cases were evaluated. A series of 15 criteria were measured on each of the final dental casts and panoramic radiographs. The data showed that 85% of the inadequacies in the final results occurred in seven of the 15 criteria (alignment, marginal ridges, buccolingual inclination, overjet, occlusal relationships, occlusal contacts, root angulation).

Therefore, at the 1996 phase III examination, a second field-test was initiated to verify the results of the previous test and to determine if multiple examiners could score the records reliably and consistently. In this field test, a subcommittee of four Directors evaluated 300 sets of post-treatment dental casts and panoramic radiographs. Again, the majority of the inadequacies in the final results occurred in the same seven categories, but the committee had difficulty establishing adequate inter-examiner reliability. The subcommittee recommended that a measuring instrument be developed to make the measuring process more reliable.

In 1997, a third field test was performed using the modified scoring system with the addition of an instrument to measure the various criteria more accurately. All of the Directors participated in this field test, and a total of 832 dental casts and panoramic radiographs were measured. The same seven criteria were evaluated. A calibration session preceded the examination to establish more accurate use of the measuring instrument and improve the reliability of the Directors. The results again showed that the overwhelming majority of the inadequacies in the finished results occurred in the aforementioned categories. However, the Directors decided to add interproximal contacts to the scoring system to raise the total number of criteria to eight. In addition, modifications were made in the measuring instrument to improve measuring accuracy among Directors.

In 1998, the fourth and final field test was initiated. Again all Directors participated in the evaluation process. The new and

improved measuring instrument was used. An extensive training and calibration session was performed prior to the actual examination. The major objectives of this final field test were to refine the measuring and calibration process, and to gather enough data on general performance to establish the validity or cut-off for passing this portion of the phase III examination. This field test was extremely successful. Not only did it reaffirm the benefits of using an objective system for grading the dental casts and panoramic radiographs, but also it helped to establish standards for successful completion of this portion of the phase III examination.

Based upon the collective and cumulative results of these extensive field tests, the Board decided to officially initiate the use of this Objective Grading System for candidates who were examined at the February 1999, ABO phase III examination in St. Louis. In order to assist the candidate in selecting cases that will successfully pass the examination process, the Board is providing the candidate with the same system used by the Directors. The Board encourages candidates to score their own dental casts and panoramic radiographs during their preparation for the phase III examination in order to select cases that will successfully pass the ABO Objective Grading System.

CRITERIA AND RATIONALE

The ABO Objective Grading System for scoring dental casts and panoramic radiographs contains eight criteria. These are: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation. The rationale for using these criteria is stated in the following section.

Alignment is usually a fundamental objective of any orthodontic treatment plan. Therefore, it seems reasonable that any assessment of quality of orthodontic result must contain an assessment of tooth alignment. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labial-incisal surfaces of the mandibular anterior teeth were chosen as the guide to assess anterior alignment. These are not only the functioning areas of these teeth, but they also influence esthetics if they are not arranged in proper relationship. In the maxillary posterior region, the mesiodistal central groove of the premolars and molars is used to assess adequacy of alignment. In the mandibular arch, the buccal cusps of

the premolars and molars are used to assess proper alignment. These areas were chosen since they represent easily identifiable points on the teeth, and represent the functioning areas of the posterior teeth. The results of the four field tests show that the most commonly malaligned teeth were the maxillary and mandibular lateral incisors and second molars, which accounted for nearly 80% of the mistakes.

Marginal ridges are used to assess proper vertical positioning of the posterior teeth. In patients with no restorations, minimal attrition, and no periodontal bone loss, the marginal ridges of adjacent teeth should be at the same level. If the marginal ridges are at the same relative height, the cementoenamel junctions will be at the same level. In a periodontally healthy individual, this will result in flat bone level between adjacent teeth. In addition, if marginal ridges are at the same height, it will be easier to establish proper occlusal contacts, since some marginal ridges provide contact areas for opposing cusps. Based upon the four field tests, the most common mistakes in marginal ridge alignment occurred between the maxillary first and second molars. The second most common problem area was between the mandibular first and second molars.

Buccolingual inclination is used to assess the buccolingual angulation of the posterior teeth. In order to establish proper occlusion in maximum intercuspation and avoid balancing interferences, there should not be a significant difference between the heights of the buccal and lingual cusps of the maxillary and mandibular molars and premolars. The Directors use a special step gauge to assess this relationship. Some latitude is allowed, however in past field tests significant problems were observed in the buccolingual inclination of the maxillary and mandibular second molars.

Occlusal relationship is used to assess the relative anteroposterior position of the maxillary and mandibular posterior teeth. In order to achieve accuracy and reliability in measuring this relationship, results of previous field tests have shown that the most verifiable method of scoring this criterion is to use Angle's relationship. Therefore, the buccal cusps of the maxillary molars, premolars, and canines must align within 1 mm of the interproximal embrasures of the mandibular posterior teeth. The mesiobuccal cusp of the maxillary first molar must align within 1 mm of the buccal groove of the mandibular first molar.

Occlusal contacts are measured to assess the adequacy of the posterior occlusion. Again, a major objective of orthodontic treatment is to establish maximum intercuspation of opposing teeth. Therefore, the functioning cusps are used to assess the adequacy of this criterion; i.e., the buccal cusps of the mandibular molars and premolars, and the lingual cusps of the maxillary molars and premolars. If cusp form is small or diminutive, that cusp is not scored. In past field tests, the most common problem area has been inadequate contact between maxillary and mandibular second molars.

Overjet is used to assess the relative transverse relationship of the posterior teeth, and the anteroposterior relationship of the anterior teeth. In the posterior region, the mandibular buccal cusps and maxillary lingual cusps are used to determine proper position within the fossae of the opposing arch. In the anterior region, the mandibular incisal edges should be in contact with the lingual surfaces of the maxillary anterior teeth. In past field tests, the common mistakes in overjet have occurred between the maxillary and mandibular incisors and second molars.

Interproximal contacts are used to determine if all spaces within the dental arch have been closed. Persistent spaces between teeth after orthodontic therapy are not only unesthetic, but can lead to food impaction. In past field tests, spacing is generally not a major problem with ABO cases.

Root angulation is used to assess how well the roots of the teeth have been positioned relative to one another. Although the panoramic radiograph is not the perfect record for evaluating root angulation, it is probably the best means possible for making this assessment. If roots are properly angulated, then sufficient bone will be present between adjacent roots, which could be important if the patient were susceptible to periodontal bone loss at some point in time. If roots are dilacerated, then they are not graded. In past field tests, the common mistakes in root angulation occurred in the maxillary lateral incisors, canines, second premolars, and mandibular first premolars.

GUIDE FOR GRADING CLINICAL CASE REPORTS
MODEL ANALYSIS

ALIGNMENT

In the maxillary and mandibular anterior regions, proper alignment is characterized by coordination of alignment of the incisal edges and lingual incisal surfaces of the maxillary incisors and canines (fig. 1), and the incisal edges and labial incisal surfaces of the mandibular incisors and canines (fig. 2).



figure 1



figure 2

In the mandibular posterior quadrants, the mesiobuccal and distobuccal cusps of the molars and premolars should be in the same mesiodistal alignment. In the maxillary arch, the central grooves (mesio-distal) should all be in the same plane or alignment (fig. 3). If all teeth are in alignment, or within 0.50 mm of proper alignment, no points are subtracted from the candidate's score.

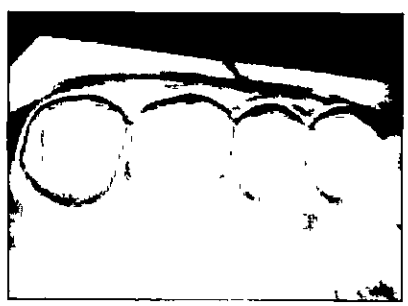


figure 3

If the mesial or distal alignment at any of the contact points is 0.50 mm to 1 mm deviated from proper alignment (fig. 4a,b), 1 point shall be subtracted for the tooth that is out of alignment. If adjacent teeth are out of alignment, then 1 point should be subtracted for each tooth.



figure 4a figure 4b

If the discrepancy in alignment of a tooth at the contact point is greater than 1 mm, then 2 points shall be subtracted for that tooth (fig. 5a,b). No more than 2 points shall be subtracted for any tooth.

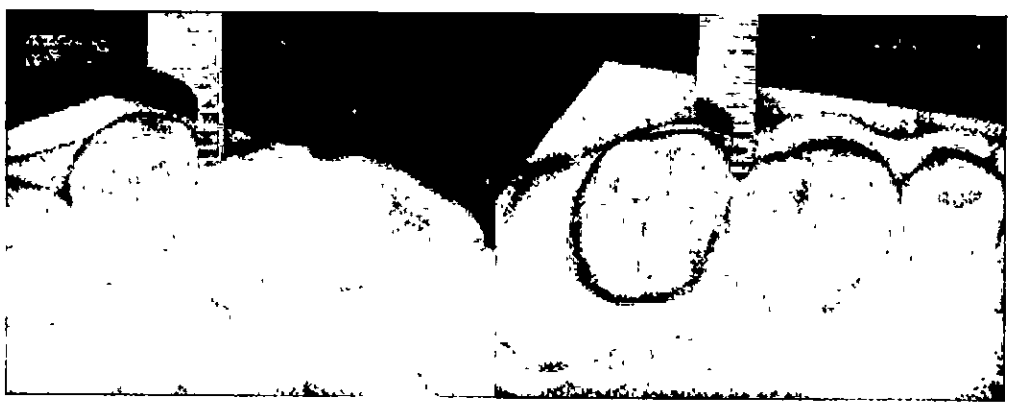


figure 5a figure 5b

MARGINAL RIDGES

In both maxillary and mandibular arches, marginal ridges of adjacent posterior teeth shall be at the same level, or within 0.50 mm of the same level (fig. 6).

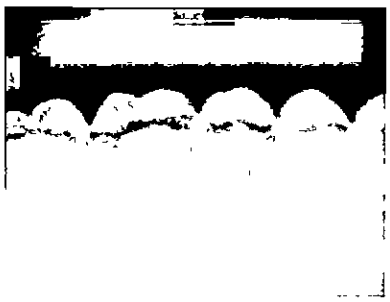


figure 6

If adjacent marginal ridges deviate from 0.50 to 1 mm (fig. 7), then 1 point shall be subtracted for that interproximal contact. If the marginal ridge discrepancy is greater than 1 mm (fig. 8), then 2 points shall be subtracted for that interproximal contact. No more than 2 points will be subtracted for any contact point. The marginal ridge will be considered as the most occlusal point that is within 1 mm of the contact at the occlusal surface of adjacent teeth.

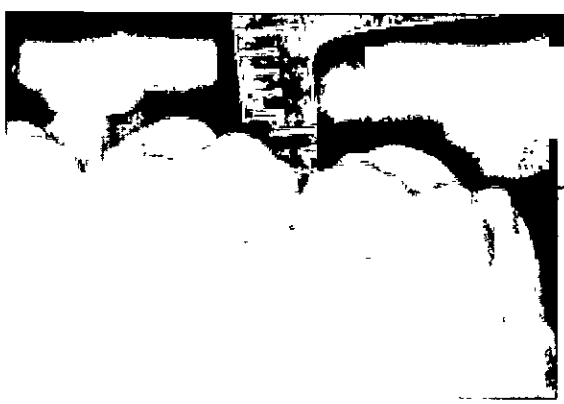


figure 7

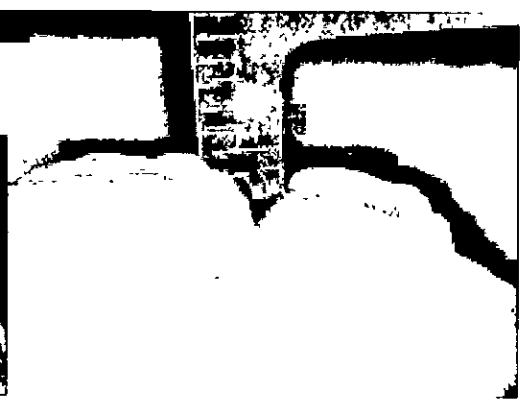


figure 8

BUCCOLINGUAL INCLINATION

The buccolingual inclination of the maxillary and mandibular posterior teeth shall be assessed by using a flat surface that is extended between the occlusal surfaces of the right and left posterior teeth. When positioned in this manner, the straight edge should contact the buccal cusps of contralateral mandibular molars. The lingual cusps should be within 1 mm of the surface of the straight edge (fig. 9). In the maxillary arch, the straight edge should contact the lingual cusps of the maxillary molars and premolars.

The buccal cusps should be within 1 mm of the surface of the straight edge (fig. 10).



figure 9



figure 10

If the mandibular lingual cusps or maxillary buccal cusps are more than 1 mm, but less than 2 mm from the straight edge surface (fig. 11a,b), 1 point shall be subtracted for that tooth.



figure 11a



figure 11b



figure 12a

figure 12b

If the discrepancy is greater than 2 mm (fig. 12a,b), then 2 points are subtracted for that tooth. No more than 2 points shall be subtracted for any tooth.

OCCLUSAL CONTACTS

This section of the evaluation determines the adequacy of occlusal contact of the premolars and molars. The buccal cusps of the mandibular premolars and molars (fig. 13) and the lingual cusps of the maxillary premolars and molars (fig. 14) should be contacting the occlusal surfaces of the opposing teeth. Each mandibular premolar has one functional cusp. Each mandibular molar has two functional buccal cusps. The maxillary premolars have one functional lingual cusp. However, the maxillary molars may have only a mesiolingual functional cusp.



figure 13

figure 14

If the distolingual cusp is short or diminutive (fig. 15), it should not be considered in the evaluation. If this cusp is prominent, but does not contact with the opposing arch, then points may be deducted. If the cusps are in contact with the opposing arch, no points are deducted.



figure 15

If a cusp is out of contact with the opposing arch, and the distance is 1 mm or less (fig. 16), then 1 point is subtracted for that cusp. If the cusp is out of contact and the distance is greater than 1 mm (fig. 17), then 2 points are subtracted for that cusp. No more than 2 points are subtracted for each cusp.

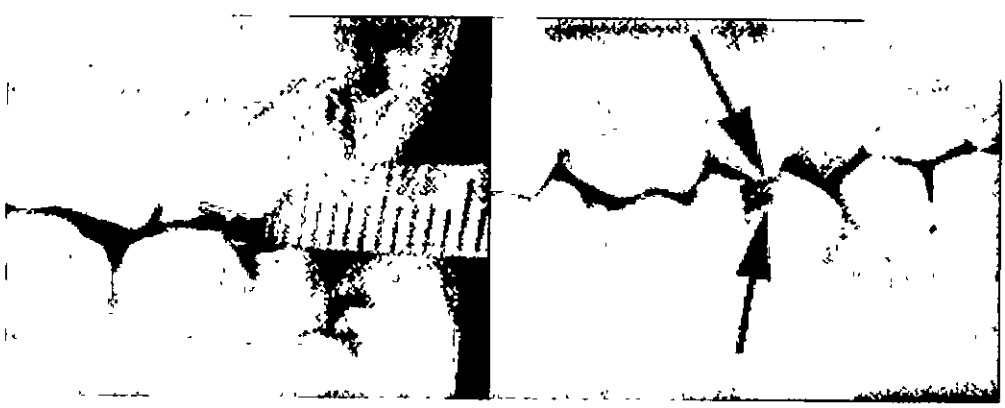


figure 16

figure 17

OCCLUSAL RELATIONSHIP

This section of the evaluation determines whether the occlusion has been finished in an Angle Class I relationship. Ideally, the maxillary canine cusp tip should align with (or within 1 mm of) the embrasure or contact between the mandibular canine and adjacent premolar (fig. 18). The buccal cusps of the maxillary premolars should align with (or be within 1 mm of) the embrasures or contacts between the mandibular premolars and first molar (fig. 18). The mesiobuccal cusps of the maxillary molars should align with (or be within 1 mm of) the buccal grooves of the mandibular molars (fig. 18).

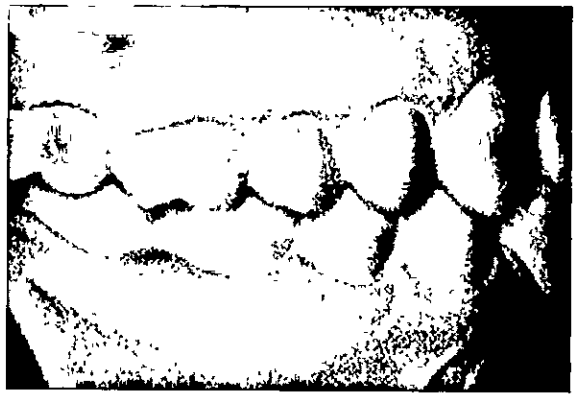


figure 18

If the maxillary buccal cusps deviate between 1 and 2 mm from the aforementioned positions (fig. 19), then 1 point shall be subtracted for that maxillary tooth. If the buccal cusps of the maxillary premolars or molars deviate by more than 2 mm from ideal position (fig. 20), then 2 points shall be subtracted for each maxillary tooth that deviates. No more than 2 points shall be subtracted for each maxillary tooth. In some situations, the posterior occlusion may be finished in either an Angle Class II or Class III relationship, depending upon the type of tooth extraction in the maxillary or mandibular arches.

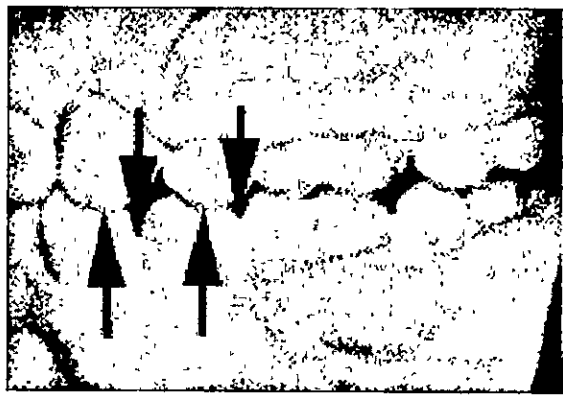


figure 19

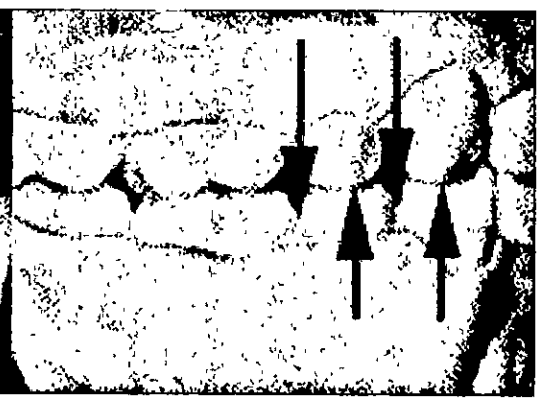


figure 20

In a Class II situation (fig. 21), the buccal cusp of the maxillary first molar should align with the embrasure or interproximal contact between the mandibular second premolar and first molar. The buccal cusp of the maxillary second molar should align with the embrasure or interproximal contact between the mandibular first and second molars. If the final occlusion is finished in a Class III relationship (when mandibular premolars are extracted), the buccal cusp of the maxillary second premolar should align with the buccal groove of the mandibular first molar (fig. 22). The remaining occlusion distal to the maxillary second premolar and mandibular first molar are adjusted accordingly.

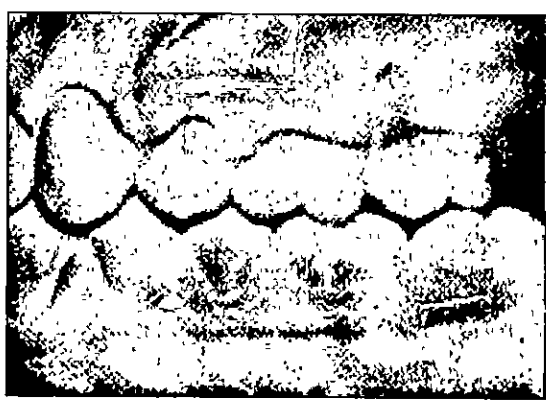


figure 21



figure 22

OVERJET

The overjet is evaluated by articulating the models and viewing the labiolingual relationship of the maxillary arch relative to the mandibular arch. In order to determine the proper relationship of the casts, the examiner must rely on the trimming of the backs of the bases of the models. The models are set flat on their backs, in order to determine this assessment (fig. 23).

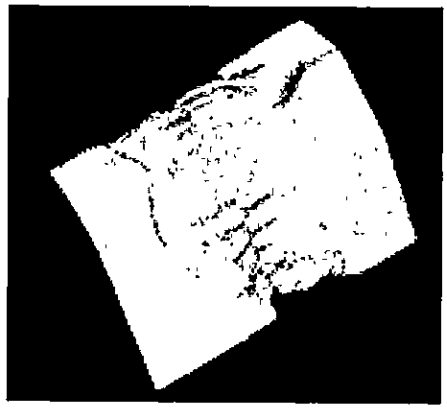


figure 23

If the models are mounted on an articulator, then the articulated mounting shall determine the proper maxillary and mandibular model relationship. If the proper overjet has been established, then the buccal cusps of the mandibular molars and premolars will contact in the center of the occlusal surfaces, buccolingually, of the maxillary premolars and molars (fig. 24). In the anterior region, the mandibular canines and incisors will contact the lingual surfaces of the maxillary canines and incisors (fig. 25). If this relationship exists, no points are subtracted.

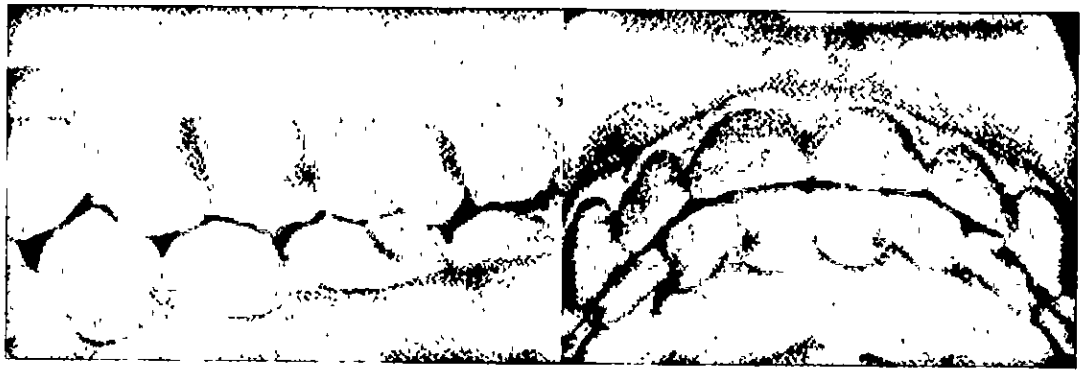


figure 24

figure 25

If the mandibular buccal cusps deviate 1 mm or less from the center of the opposing tooth (fig. 26), 1 point is subtracted for that tooth, If the position of the mandibular buccal cusps deviates more than 1 mm from the center of the opposing tooth (fig. 27), two points are subtracted for that tooth. No more than 2 points are subtracted for any tooth.



figure 26

figure 27

In the anterior region, if the mandibular canines or incisors are not contacting lingual surfaces of the maxillary canines and incisors, and the distance is 1 mm or less (fig. 28), then 1 point is subtracted for each maxillary tooth. If the discrepancy is greater than 1 mm (fig. 29), then 2 points are subtracted for each maxillary tooth.



figure 28

figure 29

INTERPROXIMAL CONTACTS

This assessment is made by viewing the maxillary and mandibular dental casts from an occlusal perspective. The mesial and distal surfaces of the teeth should be in contact with one another (fig. 30). If 0.50 mm or less interproximal space exist, then no points are subtracted.

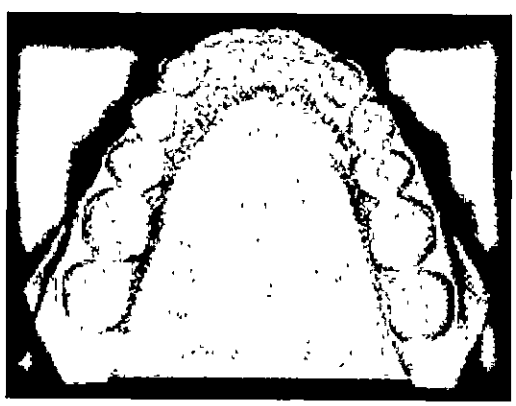


figure 30

If greater than 0.50 to 1 mm of interproximal space exists between two adjacent teeth (fig. 31), then 1 point is subtracted for that interproximal contact. If more than 1 mm of space is present between two teeth (fig. 32), then 2 points are subtracted for that interproximal contact. No more than 2 points are subtracted for any contact that deviates from ideal.

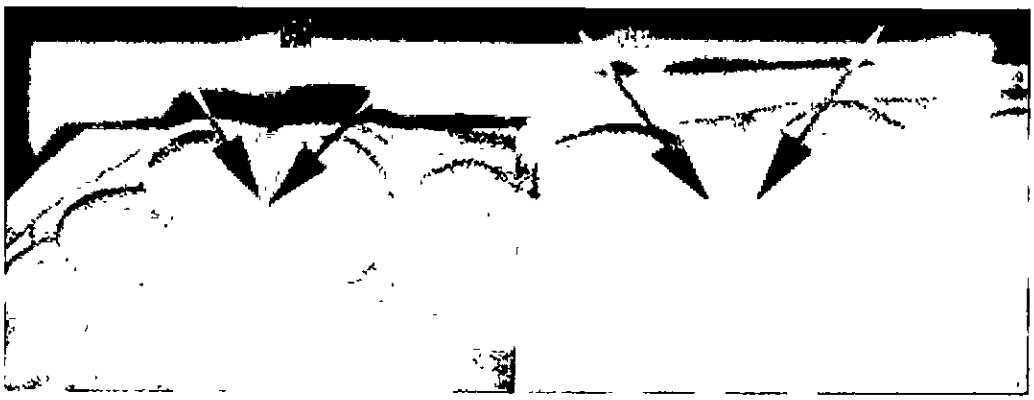


figure 31

figure 32

RADIOGRAPHIC ANALYSIS

ROOT ANGULATION

The relative angulation of the roots of the maxillary and mandibular teeth is assessed on the panoramic radiograph. Although this is not ideal, it gives a reasonably good assessment of root position. Generally, the roots of the maxillary and mandibular teeth should be parallel to one another and oriented perpendicular to the occlusal plane (fig. 33). If this situation exists, or if a deviation of the apex is 1 mm or less, then no points are subtracted.



figure 33

If a root is angled to the mesial or distal on the panoramic radiograph, and if the discrepancy is mild, with the apex of the affected tooth greater than 1 mm, but not touching the adjacent tooth root (fig. 34), then 1 point is subtracted for that tooth. If the root is angled to the mesial or distal and is contacting the adjacent tooth root (fig. 35), then 2 points are subtracted for that tooth.



figure 34



figure 35

PASSING SCORE

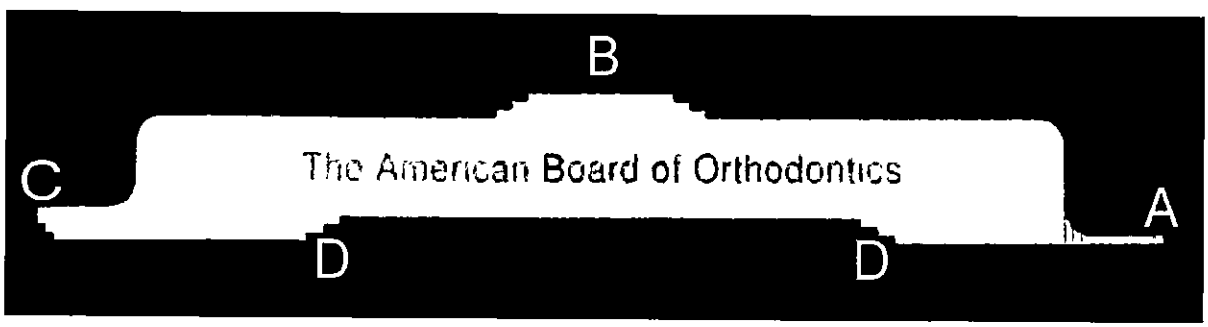
During the 1997 and 1998 field tests, both subjective and objective methods of scoring the dental casts and panoramic radiographs were used by the Directors. Based upon a comparison of these two methods, a passing score was established. In general, a case report that loses more than 30 points will fail. A case report that loses less than 20 points will generally pass that portion of the phase III examination. However, this figure only represents a part of the overall score for each case report. The quality of the records, appropriateness of the treatment plan, and objectives for positioning of the maxilla, mandible, maxillary dentition, mandibular dentition, and facial profile are also carefully scrutinized. The Board is presently field testing objective methods for grading these other aspects of the phase III examination.

SUMMARY

The Directors of The American Board of Orthodontics have spent countless hours developing this system for assessing the occlusal and radiographic results of orthodontic treatment. The usefulness of this system depends not only on its objectivity, but more importantly on the validity and reliability of the measurements. After repeated comparison of both objective and subjective systems, the Directors are confident that the "cut-off" score to pass this portion of the phase III examination is valid. Reliability will be insured through the use of a precise measuring instrument, in addition to training and calibration of the Directors before each examination. In order to be fair to all candidates, a confidence interval is established to account for interrater variability.

Although the underlying purpose of establishing this grading system is to insure reliable, objective evaluation of orthodontic records, the Board sees a much greater benefit to publishing this grading system. In the future, candidates may grade their own results before the phase III examination. Candidates will know if their results will pass the CCROE portion of the phase III examination. Furthermore, Diplomates may use this scoring system at anytime in their clinical career to determine if they are producing "Board quality" results. The Board hopes that this method of self-evaluation will help to elevate the quality of orthodontic care in the future.

THE AMERICAN BOARD OF ORTHODONTICS MEASURING GAUGE



A This portion of the gauge is 1 mm in width and is used to measure discrepancies in alignment, overjet, occlusal contact, interproximal contact, and occlusal relationships.

B This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in mandibular posterior buccolingual inclination.

C This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in marginal ridges.

D This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in maxillary posterior buccolingual inclination.

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THE AMERICAN BOARD OF ORTHODONTICS
Dental Cast Grading System
Crib Sheet

ALIGNMENT

.5 - 1 mm = -1 for each tooth
> 1 mm = -2 for each tooth

MARGINAL RIDGES*

.5 - 1 mm = -1 for each posterior tooth interproximal contact
> 1 mm = -2 for each posterior tooth interproximal contact

* Do not include the canine premolar contact.
Do not include the distal of lower 1st premolar.

BUCCOLINGUAL INCLINATION**

0 - 1 mm = satisfactory
1 - 2 mm = -1 for each posterior tooth
> 2 mm = -2 for each posterior tooth

** Do not score the mandibular 1st premolars.
Upper 2nd molars can deviate up to 2 mm with no points deducted in transverse discrepancy cases. Then: 2 - 3 mm = -1

> 3 mm = -2

OCCLUSAL CONTACTS***

Contact = 0
0 - 1 mm = -1 for each posterior tooth cusp
> 1 mm = -2 for each posterior tooth cusp

*** Do not score the distolingual cusps of the maxillary 1st and 2nd molars if they are small.
Do not score the lingual cusp of maxillary 1st premolars.

OCCLUSAL RELATIONSHIPS

0 - 1 mm = satisfactory
1 - 2 mm = -1 for each maxillary tooth from the canines to the 2nd molars inclusive
> 2 mm = -2 for each maxillary tooth from the canines to the 2nd molars inclusive

OVERJET

0 - 1 mm = -1 for each maxillary tooth
> 1 mm = -2 for each maxillary tooth

INTERPROXIMAL CONTACTS

.5 - 1 mm = -1 for each interproximal contact
> 1 mm = -2 for each interproximal contact

NOTE:

Gauge width = .5 mm
Gauge height = 1 mm

ROOT ANGULATION

Parallel = 0
Not Parallel = -1 for each tooth
Root contacting
adjacent root = -2 for each tooth

NOTE: Third molars are scored if they have erupted. If they are partially erupted or scheduled for extraction, they are not scored.

APPENDIX 12. The ABO Database for Non-orthodontists

IDS	Alignment	Marginal Ridges	B-C Inclination	occ contact	occ relation	overjet	Interproximal contact	Total
12042	7	5	3	0	1	1	0	17
12057	15	3	5	2	4	8	0	37
18039	6	5	8	0	7	0	2	28
18434	8	3	3	0	1	4	2	21
19294	13	6	2	0	12	3	3	39
20175	5	5	2	2	0	3	1	18
22205	20	4	5	0	12	3	0	44
22806	4	5	6	8	0	3	2	28
24730	11	4	4	6	1	7	1	34
24854	2	4	6	3	0	0	0	15
24914	14	10	1	15	0	9	0	49
24916	11	3	5	10	4	1	0	34
24932	13	3	8	5	10	11	0	50
24934	2	3	2	3	0	8	0	18
25829	4	7	0	0	1	10	3	25
25841	9	16	4	1	4	0	2	36
25857	16	2	6	0	0	8	0	32
28705	1	0	1	0	0	0	9	11
28731	8	7	2	0	16	13	16	62
28754	9	1	2	2	0	3	0	17
28787	4	4	1	3	3	5	0	20
28858	2	4	1	7	3	6	7	30
28017	11	3	3	1	4	6	0	28
28036	3	4	6	5	10	8	2	38
28923	13	12	4	20	5	5	0	59
28948	12	3	2	7	0	2	3	29
30558	4	4	5	10	2	3	0	28
30658	2	5	9	17	2	5	0	40
30833	7	2	1	0	0	3	0	13
32010	10	0	4	6	6	2	2	30
32058	8	2	3	3	2	2	0	20
32088	14	2	3	0	3	6	2	30
34027	3	2	5	5	1	4	0	20
34051	5	8	3	0	9	1	0	26
34056	4	5	8	0	3	0	0	20
34059	10	2	4	2	4	4	0	26
36006	28	0	11	15	4	4	0	62
36008	4	3	0	4	0	0	0	11
36009	3	3	6	2	3	3	0	20
36016	11	4	2	3	3	6	0	29
36018	6	4	3	15	0	1	0	29
36023	10	9	2	11	7	10	0	49
36025	1	6	2	0	0	3	0	12
36040	8	3	1	6	1	1	0	20
36041	2	6	6	2	8	0	0	24
38002	6	3	7	2	1	4	0	23
38007	3	4	4	13	0	1	0	25
38021	14	6	16	17	3	2	0	58
38022	4	9	2	14	3	1	0	33
40012	5	8	8	3	2	3	0	29
40031	9	8	2	8	8	3	10	48
40043	20	7	2	4	0	6	0	39
40068	6	3	2	6	6	5	2	30
40073	3	2	11	4	0	0	0	20
40091	2	2	1	0	0	6	0	11
40139	5	3	9	0	2	1	0	20
42005	8	2	6	2	2	2	0	22
42006	12	2	7	4	2	2	4	33
42045	12	8	2	18	10	6	0	56
42062	4	6	1	1	2	1	1	16
42063	12	12	2	2	2	4	0	34
42089	2	3	5	5	3	2	0	20
44011	2	3	0	3	5	3	0	16
44025	5	2	4	3	6	1	2	23
44027	12	3	7	3	0	1	0	26
44030	5	2	6	2	3	2	0	20
44035	3	5	7	6	4	0	1	26
44040	7	2	7	12	5	8	0	41
44050	9	2	2	4	2	5	0	24
44054	13	5	3	7	4	10	8	50

Appendix 13. The ABO Database for Orthodontic Specialists

IDS	Alignment	Marginal Ridges	B-C Inclination	occ contact	occ relation	overjet	interproximal contact	Total
14020	3	2	1	1	4	6	0	17
14024	8	3	5	0	6	2	0	24
14027	7	2	4	1	4	3	0	21
14038	6	3	2	4	3	4	0	22
14049	8	8	2	4	4	6	0	32
14054	2	1	4	0	0	0	0	7
14073	2	6	2	1	10	12	2	35
19086	1	7	4	0	0	0	2	14
20081	6	4	12	3	6	3	2	36
20105	4	2	2	2	7	3	0	20
20126	3	3	2	4	2	4	0	18
20132	4	0	0	1	0	1	0	6
20136	2	4	0	3	0	1	0	10
20137	4	2	6	0	0	2	0	14
20138	8	4	7	9	0	3	0	31
20144	4	1	4	12	2	5	0	28
20159	2	4	2	8	1	1	1	19
20225	7	2	8	1	6	1	0	25
20227	2	4	0	4	10	0	0	20
20240	10	5	5	5	8	6	0	39
20265	2	8	2	13	0	3	0	28
20271	7	3	8	6	4	5	2	35
20273	9	4	7	0	2	0	0	22
20307	16	4	5	8	4	8	3	48
20315	1	1	6	5	0	0	0	13
20316	3	5	3	3	0	0	2	16
20324	8	7	3	4	1	2	2	27
20339	2	4	0	2	0	2	0	10
20342	2	9	6	1	8	0	0	26
20361	9	8	2	4	12	7	0	42
20363	5	3	23	0	0	0	0	31
20366	6	5	4	8	0	6	0	29
20370	7	6	5	2	0	3	0	23
20375	6	6	5	0	8	0	0	25
20378	6	4	7	0	2	3	2	24
20380	4	7	9	4	2	2	0	28
20401	0	4	1	3	12	0	0	20
20405	6	2	0	10	0	6	0	24
20410	3	3	3	0	0	8	0	17
20418	3	4	4	0	0	8	0	19
20435	7	4	7	8	2	10	0	38
20437	4	4	3	0	0	9	0	20
20439	7	3	6	2	2	2	1	23
20453	7	5	2	6	4	4	0	28
20461	2	6	7	13	0	4	0	32
20478	2	3	4	0	10	0	0	19
20485	5	3	1	0	2	6	0	17
20499	6	6	10	10	10	14	0	56
20500	7	2	1	8	6	1	2	27
20502	4	7	9	11	0	4	0	35
20504	25	1	6	0	2	8	0	42
20525	1	0	0	0	0	0	8	9
22187	6	6	4	1	2	0	0	19
22218	2	5	1	3	0	11	0	22
22823	5	5	4	6	4	1	0	25
24183	1	8	4	0	2	2	0	17
24483	11	3	0	2	0	7	2	25
24545	2	1	3	7	1	2	2	18
24547	6	3	3	1	1	5	0	19
24573	3	1	17	2	5	3	0	31
24581	1	6	1	3	3	2	0	16
24588	2	0	0	11	10	10	4	37

IDS	Alignment	Marginal Ridges	B-C Inclination	occ contact	occ relation	overjet	Interproximal contact	Total
24595	1	3	4	7	0	3	0	18
24697	4	3	7	6	2	8	0	30
24714	9	2	17	2	0	0	0	30
24717	1	5	2	9	1	4	0	22
24750	5	5	4	12	1	0	1	28
24798	8	7	4	0	0	2	0	21
24841	7	3	2	2	8	3	0	25
24842	4	0	7	5	0	2	0	18
24845	4	20	8	12	12	2	0	58
24848	11	3	2	2	8	14	0	40
24862	3	4	7	13	2	14	1	44
24883	5	5	5	1	4	0	0	20
24884	5	3	7	8	8	8	0	39
26635	4	1	0	2	0	0	5	12
26664	5	6	2	0	3	5	2	23
26681	8	3	5	2	1	2	3	24
26682	0	0	3	3	4	2	1	13
26718	1	2	0	0	4	4	3	14
26721	2	3	11	10	2	0	0	28
26735	9	0	0	0	3	6	0	18
26737	5	3	4	2	1	4	0	19
28025	6	6	1	3	7	0	1	24
28871	5	5	6	6	7	2	0	31
28959	2	1	10	2	2	6	0	23
28960	2	4	6	1	6	2	0	21
28980	4	3	2	12	0	13	0	34
28992	6	0	2	5	2	2	0	17
30201	3	3	6	2	0	7	1	22
30223	4	4	1	6	1	1	0	17
30592	2	5	2	15	4	16	4	48
30653	3	10	4	3	1	2	0	23
30659	11	4	0	6	4	4	0	29
30670	8	13	8	4	6	2	5	46
30702	0	2	11	9	1	5	2	30
30740	5	10	11	4	1	11	0	42
30743	5	2	4	0	5	4	1	21
30830	19	4	3	6	5	7	0	44
32027	1	2	2	0	1	18	0	24
32069	7	4	17	2	0	3	0	33
32078	5	0	1	5	3	1	2	17
36004	1	0	4	0	0	0	0	5
36007	10	1	10	0	0	8	0	29
36014	2	5	2	2	0	1	1	13
36030	6	8	5	3	0	4	0	26
36033	12	3	2	0	4	3	0	24
36037	17	5	0	0	7	1	0	30
40009	7	3	11	2	5	1	0	29
40010	15	6	0	1	3	9	0	34
40013	0	2	2	3	5	2	2	16
40018	3	1	4	0	0	4	0	12
40024	5	1	0	3	1	3	2	15
40027	3	2	6	4	2	1	0	18
40052	3	9	2	22	1	6	4	47
40058	3	2	3	2	0	1	0	11
40074	7	2	13	5	6	5	5	43
40077	9	1	1	20	1	7	0	39
40079	6	4	9	0	14	10	0	43
40092	7	3	2	2	1	7	6	28
40096	2	2	11	1	0	0	0	16
40097	6	9	3	10	11	6	2	47
42009	27	7	5	8	7	16	0	70
42010	2	5	2	0	0	1	5	15
42037	3	0	4	0	0	6	0	13
44034	11	4	2	4	10	7	2	40

APPENDIX 14. The Q-sorts scoring Sheet

Q-sorts Scoring Sheet

Name

	POOR	AVERAGE	GOOD		POOR	AVERAGE	GOOD		POOR	AVERAGE	GOOD
1				41				81			
2				42				82			
3				43				83			
4				44				84			
5				45				85			
6				46				86			
7				47				87			
8				48				88			
9				49				89			
10				50				90			
11				51				91			
12				52				92			
13				53				93			
14				54				94			
15				55				95			
16				56				96			
17				57				97			
18				58				98			
19				59				99			
20				60				100			
21				61							
22				62							
23				63							
24				64							
25				65							
26				66							
27				67							
28				68							
29				69							
30				70							
31				71							
32				72							
33				73							
34				74							
35				75							
36				76							
37				77							
38				78							
39				79							
40				80							

APPENDIX 15 The Q-sorts Database for non-orthodontists

Appendix 15. The Q-sorts Database for orthodontics specialists

IMPID	#POBOR	EX.1	Ex.2	EX.3	EX.4	EX.5	EX.6	EX.7	Ex.8	Ex.9	SUM
20	OR	3	3	2	2	2	3	3	3	3	24
14027	OR	3	2	2	1	2	1	2	3	2	18
38	OR	2	1	2	1	1	2	3	3	1	16
54	OR	3	3	2	2	2	3	2	3	3	23
73	OR	1	1	2	1	1	1	1	1	1	10
81	OR	2	2	2	2	2	1	2	2	1	16
132	OR	3	1	2	1	1	3	2	2	2	17
138	OR	3	3	2	2	2	1	2	3	3	21
144	OR	1	1	1	1	1	1	1	1	1	9
225	OR	2	1	2	1	1	1	1	2	1	12
227	OR	2	1	2	1	2	1	2	2	1	14
240	OR	3	2	2	1	1	1	2	3	2	17
271	OR	2	1	1	1	2	1	1	3	1	13
273	OR	3	3	2	1	2	3	2	3	2	21
307	OR	1	1	2	1	1	1	1	2	1	11
315	OR	3	2	3	3	2	3	3	3	2	24
318	OR	3	2	2	3	1	2	3	3	2	21
330	OR	3	3	2	2	2	3	2	3	3	23
401	OR	1	3	2	2	1	2	3	3	2	19
435	OR	3	1	1	2	1	2	2	1	2	15
439	OR	2	3	3	2	2	2	2	2	3	21
469	OR	3	1	2	1	1	3	2	2	1	16
500	OR	1	1	2	1	1	1	2	1	1	11
587	OR	3	3	2	2	2	3	1	3	3	22
623	OR	3	2	3	2	1	2	2	3	1	19
673	OR	1	2	1	2	1	1	1	1	1	11
691	OR	3	3	2	1	2	3	3	3	2	22
714	OR	3	1	2	2	2	2	2	2	3	19
750	OR	3	3	3	3	2	2	3	3	2	24
841	OR	2	1	2	2	2	1	2	3	2	17
842	OR	3	3	3	3	2	2	2	2	3	23
Heather	OR	1	1	2	1	1	1	1	1	1	10
854	OR	2	1	2	1	1	1	1	2	2	13
882	OR	3	2	3	2	3	1	2	2	1	19
721	OR	3	2	3	2	2	1	2	3	3	21
25	OR	3	1	2	1	2	2	2	2	1	16
959	OR	3	1	2	1	1	1	2	1	2	14
960	OR	2	1	3	2	2	2	2	2	1	17
980	OR	1	1	1	1	1	1	1	1	1	9
223	OR	2	1	1	2	2	2	2	2	2	16
982	OR	1	1	2	1	1	1	1	1	1	10
653	OR	1	1	2	1	1	2	1	1	1	11
659	OR	3	1	1	2	1	1	1	2	3	15
830	OR	1	1	1	1	1	1	1	1	1	9
898	OR	1	1	1	1	1	1	1	2	1	10
985	OR	1	1	2	1	1	1	2	2	1	12
552	OR	3	1	2	2	1	2	2	3	2	18
646	OR	3	2	2	2	2	3	2	3	3	22
644	OR	3	3	3	2	1	2	3	3	3	23
990	OR	3	3	2	1	1	2	2	2	2	18

APPENDIX 16The Q-sorts Database for Orthodontic Specialists

IMPID	SPOBDR	EX.1	Ex.2	EX.3	EX.4	EX.5	EX.6	EX.7	Ex.8	Ex.9	SUM
1082	GP	3	3	3	2	3	3	3	3	3	26
1066	GP	1	2	1	1	1	1	1	2	1	11
39	GP	1	1	1	1	2	1	1	3	2	13
434	GP	3	2	2	1	1	2	2	2	2	17
1095	GP	1	2	2	1	1	1	1	1	1	11
175	GP	3	2	2	2	2	2	2	3	3	21
205	GP	1	1	1	1	1	1	1	1	1	9
606	GP	3	1	2	2	1	1	2	2	1	15
730	GP	1	1	1	1	1	1	2	2	1	11
854	GP	3	3	3	3	3	3	3	3	3	27
1084	GP	2	1	1	1	1	1	1	2	2	12
1054	GP	2	2	2	1	1	1	2	2	1	14
1086	GP	1	1	1	1	1	1	1	1	2	10
1082	GP	3	1	2	2	1	1	2	2	3	17
641	GP	3	2	2	2	1	2	2	2	1	17
657	GP	2	1	1	1	1	1	1	1	1	10
705	GP	1	1	1	2	1	2	1	2	1	12
1112	GP	1	1	1	1	1	1	1	1	1	9
1087	GP	2	1	2	2	1	2	1	3	1	15
17	GP	3	1	2	2	1	2	1	2	1	15
36	GP	1	1	2	1	1	1	1	2	2	12
948	GP	3	1	2	1	1	2	2	3	1	16
958	GP	2	1	2	1	2	2	3	2	2	17
658	GP	1	1	1	1	1	1	2	1	1	10
1102	GP	1	1	2	1	2	1	2	2	3	15
1046	GP	3	2	3	2	1	2	2	3	3	21
1045	GP	3	2	3	3	3	3	2	3	3	25
1052	GP	1	1	2	1	1	1	2	3	2	14
991	GP	3	2	3	3	2	3	3	3	3	25
1093	GP	1	1	1	1	1	1	2	2	2	12
996	GP	2	2	2	2	1	1	2	2	2	16
954	GP	3	1	2	2	1	2	2	3	3	19
955	GP	1	1	2	1	2	1	2	2	1	13
1097	GP	3	1	3	2	1	2	2	3	2	19
1041	GP	1	1	2	1	1	1	2	1	2	12
970	GP	3	3	3	2	3	3	3	1	3	24
968	GP	2	1	2	1	1	1	1	1	1	11
915	GP	1	1	1	1	1	1	1	1	1	9
395	GP	1	1	1	1	1	1	1	1		8
969	GP	3	1	2	2	1	2	3	2	3	19
1003	GP	3	3	3	3	3	3	3	3	3	27
1044	GP	2	1	1	2	1	2	2	3	2	16
977	GP	1	1	1	1	1	1	1	1	1	9
1089	GP	3	3	2	2	1	3	2	2	2	20
1120	GP	2	2	2	1	1	1	2	3	1	15
1122	GP	3	2	2	2	2	3	3	3	2	22
984	GP	3	2	2	3	3	3	2	3	1	22
1075	GP	1	1	2	1	1	1	2	2	1	12
1096	GP	1	1	1	1	1	1	1	1	1	9
559	GP	1	1	1	1	1	1	1	1	1	9

APPENDIX 17 Q-sorts data

Examiner 1

EX1	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	21	9	20	50
Orthodontic Specialists	13	10	27	50
Grand Total	34	19	47	100

P=2.91

Examiner 2

EX.2	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	32	13	5	50
Orthodontic Specialists	27	10	13	50
Grand Total	59	23	18	100

P=0.05

Examiner 3

EX3	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	17	25	8	50
Orthodontic Specialists	9	32	9	50
Grand Total	26	57	17	100

P=0.23

Examiner 4

EX 4	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	28	17	5	50
Orthodontic Specialists	25	21	4	50
Grand Total	53	38	9	100

P=0.88

Examiner 5

EX.5	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-	37	7	6	50

Orthodontists				
Orthodontic Specialists	27	22	1	50
Grand Total	64	29	7	100

P=0.15

Examiner 6

EX.6	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	28	13	9	50
Orthodontic Specialists	24	16	10	50
Grand Total	52	29	19	100

P=0.63

Examiner 7

EX.7	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	18	24	8	50
Orthodontic Specialists	15	27	8	50
Grand Total	33	51	16	100

P=0.76

Examiner 8

EX.8	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	14	19	17	50
Orthodontic Specialists	11	18	21	50
Grand Total	25	37	38	100

P=0.38

Examiner 9

EX.9	POOR	AVERAGE	GOOD	GRAND TOTAL
Non-Orthodontists	24	14	12	50
Orthodontic Specialists	22	16	12	50
Grand Total	45	30	24	100

P=0.95

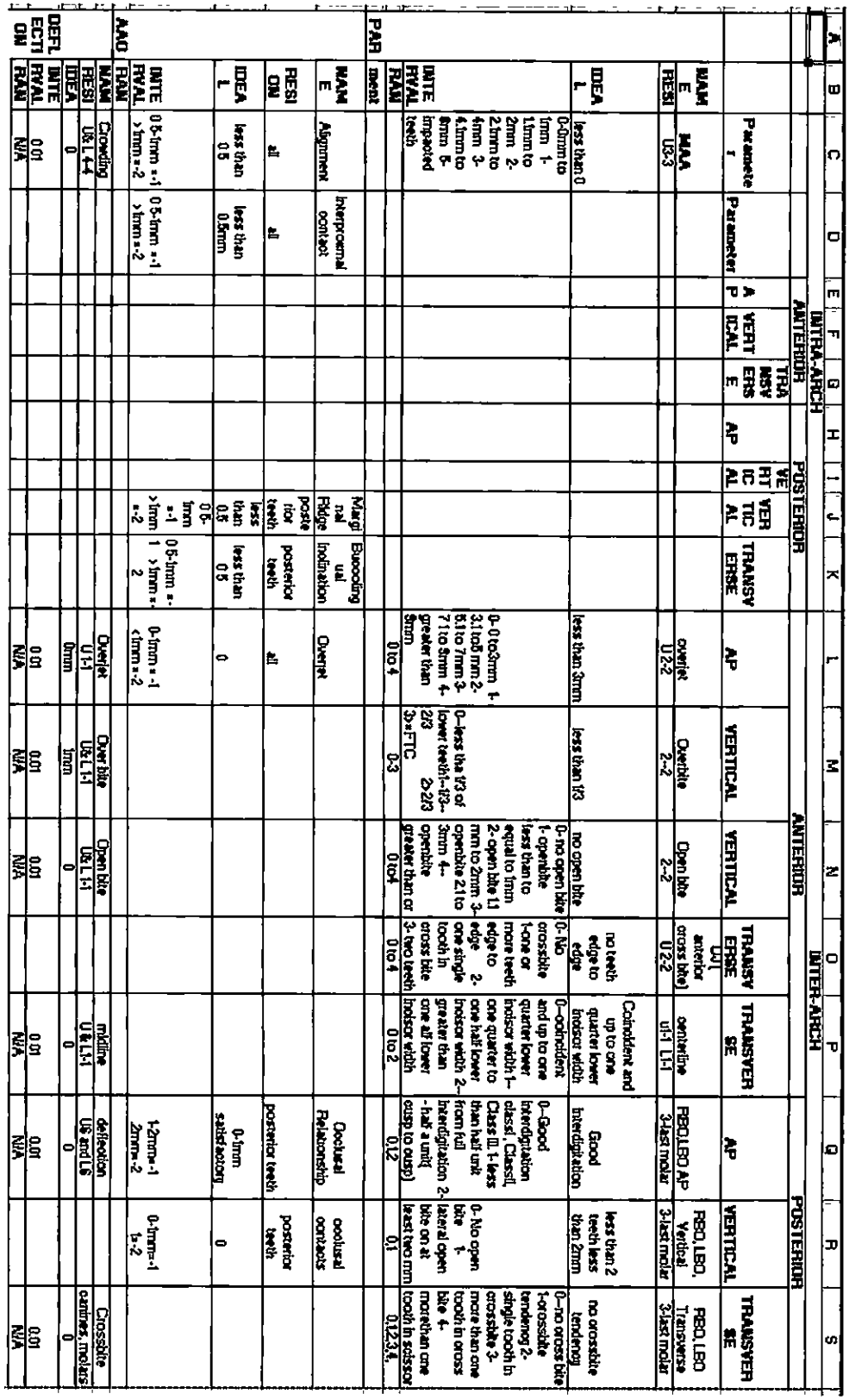
APPENDIX 18. Comparison 100 dental casts and 196 dental casts

Comparing 196 dental casts and 100 dental casts using the ABO objective grading system

	ABO 196		ABO 100	
	ORTHODONTIC SPECIALISTS	NON-ORTHODONTISTS	ORTHODONTIC SPECIALISTS	NON-ORTHODONTISTS
Ave.	29.6±12.8	26.0±11.4	28.78±10.6	26.96±10.7
P-VALU	0.04		0.39	

	PAR 196		PAR 100	
	ORTHODONTIC SPECIALISTS	NON-ORTHODONTISTS	ORTHODONTIC SPECIALISTS	NON-ORTHODONTISTS
Ave.	10.85±5.25	11.56±5.6	10.72±4.93	11.74±5.78
P-VALU	0.39		0.35	

APPENDIX 19 Comparison Of Indices



APPENDEX. 20 Publication Version 1

Outcome assessment of treatment provided by orthodontic specialists and non-orthodontists.

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ABSTRACT

The purpose of the present study was to compare the orthodontic outcome for patients treated by dentists with specialty training in orthodontics (orthodontic specialists) to the orthodontic outcome for patients treated by dentists without specialty training in orthodontics (non-orthodontists) using four different indices. The sample consisted of 196 dental casts collected in 1997 and 1998 from 1047 10^{th} grade students attending high school in Cuyahoga County, who had orthodontic treatment. All casts were scored using the Peer Assessment Rating Index (PAR), the Deflection Index (DI), the American Board of Orthodontics Objective Grading system (ABOI) and q-sort. For the Q-sorts 9 experienced orthodontists sorted these 100 casts into three groups: Good, Acceptable, and Poor. There was no significant difference between mean scores for PAR, DI, or the Q-sorts scores. However the mean ABO Objective Grading System were, 26.0±11.4 for orthodontic specialists, versus 29.6±12.8 for non-orthodontists, the difference in mean ABOI score was statistically significant ($P \leq 0.04$). Of the seven components used in the ABOI, the alignment of teeth was found to be most significant (0.0007). Thus, we conclude that the ABOI is sensitive enough to detect a difference between orthodontists and those of non-orthodontists.

INTRODUCTION

Evidence based has become a healthcare hot bottom for the new century. As such, quantitative measures of treatment outcome have been increasingly more important not only for health care providers but also for health care consumers. Dental consumers are interested in value i.e. obtaining the best quality service at the lowest cost. In a fee for service profession such as orthodontics cost comparison are fairly straightforward. Comparing quality is more subjective. The objective evidence of the orthodontic specialist's superiority in straightening crooked teeth seems easy to measure, but several factors make this area of investigation problematic. Malocclusion is the poor alignment of teeth and jaws; not a disease, but rather a collection of morphologic conditions with an indefinite cut off value between normal and abnormal. For example, facial esthetics, often considered an integral component of orthodontic treatment, is subjective and "in the eye of the beholder."

Some of the goals of orthodontic treatment are difficult to quantify i.e. healthy smile or balanced profiled. However one measure that has been a consistent goal of orthodontic therapy is straight teeth and several valid and reliable indices has been developed to measure this outcome.

In this study straightness the teeth are measured using the Peer Assessment Rating Index (PAR); the Deflection Index (DI), the ABO Objective Grading system (ABOI), and the Q-sort (QI) to evaluate the treatment outcome.

MATERIAL AND METHODS

SUBJECT

The survey data were obtained from 2,808, 10th grade students attending high school in Cuyahoga County in 1997 and 1998. Of the 2,808 subjects, 1,047 or 37 % were orthodontically treated. 890 impressions were taken, of these 255 were orthodontically treated subjects. 78 were treated by non-orthodontists, 160 were treated by orthodontic specialists, 17 were unknown. Distortion of impression material and/or incomplete database information lowered the number of subjects in the impression sample to 196. Of these 126 were treated by orthodontic specialists and 70 were treated by non-orthodontists. Using a randomizing table, 50 dental cases were selected from each group for use in the Q-sort Index. All 196 casts were used for the PAR Index, the Deflection Index and the ABO Objective Grading System scoring.

Each set of the 196 dental casts was hand articulated in maximum intercuspation without the use of a wax bite for reference. The primary investigator blinded to the identification of the providers.

The technique for the PAR scoring dental casts has been previously published (O'Brien et al.1993). The primary investigator (Y.A) was calibrated in the use of the PAR Index. To be calibrated the primary investigator was asked to PAR score 15 dental casts. And another investigator calibrated by O'Brien (Roland Feghali) scored the same 15 casts. The resulting scores were compared for reliability.

The "weighted scores" from the six components are added to obtain the total PAR score.

The technique for the Deflection Index has been previously published by Rolf Behrents at The University of Tennessee, Memphis, TN, in 1993. The Deflection Index is the sum of six components of recorded 21variables; all measurements were made with electronic

digital calipers calibrated to 0.01 mm. The over all approach to this "Deflection Index' was to measure deviations from established normal values and then simply sum across variables in order to produce a number that represents the total distance teeth must be moved to achieve excellent intra- and interarch placement.

Total deflection= overjet+overbite+midline+openbite correction+total crowding+ total molar deflection.

The primary investigator (Y.A.) was self calibrated using The ABO Objective Grading System self-calibration kits under the supervision of ABO director, Dr. Mike Riolo. The final number was the arithmetic sum of all seven dental cast measures, plus the root angulations taken from panoramic radiographs, the actual ABO Index uses. In the present study, we could not collect root angulations measurement, since we did not have access to the panoramic radiographs for these patients.

Q-sorts index was graded in three degrees, Poor, Average, and Good. All the examiners who were all experienced orthodontic specialists were blinded to the orthodontic treatment provider. One point was given to the dental casts in the "Poor" group two points were given to the dental casts in the "Average" groups, and three points were given to the dental casts in the "Good" group. The numbers of the cases from each group were counted for each examiner individually. The number of "good" cases "poor" cases from two provider groups were compared using Chi-square to see if any of the examiners could tell the orthodontic specialists cases from non-orthodontic cases. Also total Q-sort points were compared by the sum of the score for each of the casts across all the examiners.

DATA ANALYSIS

All data were entered into a computer-spread sheet (Microsoft Excel®, Micro Soft INC., Seattle, WA) by the primary investigator. The Statistical Package for Social Science (SPSS) ® was used for statistical analysis. A p-value of 0.05 was used to assign statistical significance. T-tests were used for all continuous variables including PAR, DI, and the ABOI and Q-sort totals. A chi-square was used for each Q-sort.

RESULTS

The final sample consisted of 196 sets of casts. Forty five percent were male and 55% were female. The mean PAR scores for all cases in the sample was 11.3± 5.57. The mean PAR scores according to the two providers groups are listed in Table 1. There were no significant differences between these two groups.

The mean scores for the total sample for The Deflection Index was 11.8±7.02. The Deflection Index score between orthodontic specialists and non-orthodontists (Table 2) does not show any significant differences. Although crowding scores did show a trend toward significance (P=0.08).

The mean ABO objective grading system and standard deviation of post treatment study models was 27.27± 12.0. Table 3 reports the means and standard deviations of the seven components by provider education. A significant difference was found ($p<0.05$) in the total mean score for The ABO Objective Grading System, in the alignment section.

In general, a case report that loses more than 30 points will fail the ABO examination. A case report that loses less than 20 points will generally pass that point of the phase III examination. In addition to this classification, Dr. Mike Riolo suggested to classify cases the following groups: Less than 10 = excellent, 11-19 = good 20-26 =

probably pass American Board part III, 26-30 = boarder line, may or may not pass, 30-35 = A poor, Greater than 35 =Very poor. Table 4 shows distribution of provider according to these classifications.

Only one examiner could detect significant differences between Non-specialists and specialists groups. Table 5 shows the chi-square result from Q-sort.

In order to pool the Q-sort results "1" was given for poor cases, "2" was given average cases, "3" was given for a good case. The sum of these numbers was analyzed by the t-tests. The results were shown in table 6.

A Pearson correlation was calculated to assess the magnitude of correlation between each index. The results displayed in Table 7 shows that all four indices are correlated

Approximately ten percent of sample was re measured to estimate reliability. The result of the Intra class coefficient was calculated to estimate reliability. The results are listed in table 8. The primary Investigator (Y.A) showed the excellent reliability for all indices used.

DISCUSSION

The total PAR score found in the sample of treated case (N=196) were 11.39 (SD=5.57). This falls into "Generally Acceptable Range". The means for the PAR score for orthodontic specialists and non-orthodontists were 11.68±5.54, 10.85±5.25 respectively. The non-specialists treated cases scored slightly lower, but there was no statistical significance in means of the total PAR score between these two groups, except left buccal occlusion shows significant difference (P=0.02). This can be due to the impression technique. Interestingly, Feghali (1999) found a trend toward significance between the total alginate and polybite

impression (putty polyvinylsiloxane material) score along with the Left Buccal Occlusion component (P=0.083).

DeGuzman's study concluded lower incisor and buccal segment crowding did not have a predictive effect for malocclusion severity and perceived treatment duration. This opinion may have been influenced by the comparative ease with which dental crowding is corrected by extraction of teeth or arch expansion, in contrast to the more difficult correction of overjet or midline discrepancy. Treatment difficulty and malocclusion severity were distinct but related entities, although, various components of malocclusion were not reliable predictors of perceive treatment difficulty. From the point of outcome assessment on the contrary, the traits, which can be easily corrected, should be weighted higher, because the error in the easier part shows more inferiority than error in difficult traits to correct.

In this study the American weighting system was used (DeGuzman1995), However, we were not be able to use numerical reduction in PAR, since pretreatment dental casts were not available for this study so the aspect of treatment difficulty is not considered in this study. This is an important variable, as it may affect treatment goals and in some instances may influence clinicians to accept an attainable but less than ideal treatment result. It is not totally fair to compare treatment out come only without judging case difficulty. Even though Nguyen (1999) showed no statistical significant difference in the mean pretreatment PAR score for cases treated by general dentists and orthodontists. (21.6± 9.3 and 22.2± 9.3 respectively), there is a possibility that numerical reduction in PAR score shows different result from the present study.

The deflection index requires 21 measurements measured by electric caliper. This really evaluates Overjet, Overbite, Midline, Transverse deficiency in canine and molar

lesion, Crossbites, Interdigitation of right and left molar, crowding upper and crowding lower. Total score of deflection index for orthodontic specialists and non-orthodontists were 11.18±7.50, 13.0±5.96 respectively. There was a trend toward significance (P=0.08) between these two groups along with the total crowding.

Comparing with PAR, electric digital caliper is more accurate than the PAR ruler. Less than 1mm of the crowding and equal to and less than 3mm of overjet evaluated by the PAR index will be Zero and not significant. In addition to the PAR measurements, the deflection index scores upper cuspid to bicuspid and mandibular first bicuspid to first bicuspid crowding which are not evaluated in the PAR Index.

The Defection Index measures deviation from established norm (ideal occlusion), but validity for the established value can be argued. For example The Deflection Index set ideal overjet and overbite one millimeter. For the Overjet section both incisor should be touched for the ABO index, and 3mm for the PAR Index. (Appendix 17) Also, intra arch measurements such as the interdigitation of the teeth, and the intecuspal relation are not evaluated by the Deflection Index but only first molar deviation is measured.

The ABO Objective Grading Index was invented for outcome assessment for the American Board of Orthodontics phase III examination. The eight criteria used for ABOI were chosen by the ABO examiners. They used the measurements that cover 85% of mistakes that examiners see in the phase III examination. The ABO Objective Grading System was designed to evaluate finished cases and therefore was probably best index for the present study.

In the alignment section, maxillary central groove (mesio-distal) alignment and medibuccal cusps of the mandibular molar and premolars are assessed in addition to incisor

alignment, and not only horizontal, vertical marginal ridge discrepancies, inclination of teeth, occlusal contact point, interdigitation of posterior teeth, overjet of all the teeth, those were not assessed by the other three index, were assessed by this index.

The overall mean ABOI score was 27.27±27. In general, a case score of 30 points will fail and less than 20 will generally pass that portion of ABO phase III examination. Twenty-six is the borderline for passing examination. Additionally, the quality of the record, appropriateness of the treatment plan, and objective for position of the maxilla, mandible, maxillary dentition, mandibular dentition, and facial profile are also scrutinized. In the present study, we didn't add the root angulations measurement, adding root angulations measurements section makes the score higher than 27.27±27. A significant difference was found ($p \leq 0.04$) in the total ABO score between orthodontic specialists and non-orthodontists. The alignment score which was highly significant (P=0.007) shows that orthodontic specialists are superior in straightening posterior teeth. In addition to anterior teeth alignment that both PAR and Deflection indices evaluate, ABOI alignment section examines the central groove (mesio-distal) alignment in Maxillary molar and premolars, and mediobuccal cusps of the mandibular molars and premolars. Nether the PAR Index nor the Deflection Index shows statistical difference in alignment section, only the ABOI which measures alignment of posterior teeth showed statistical difference and this makes a difference between orthodontic specialists and non-orthodontists.

Table 7 shows that 17% (n=12) of non-orthodontist cases scored less than 20and should pass the model portion of American Board of Orthodontic Phase III examination. Importantly, 32% of Orthodontists cases scored less than 20. However, scores both root

angulations, so the actual number of the people who are likely to pass the ABO from this group is slightly lower than these numbers.

Only out of the nine orthodontists detected a difference in outcome of orthodontic treatment provided by orthodontic specialists and non-orthodontists.

There were statistical significant correlations among these four indices (Table 19), Q-sort with the ABO Objective Grading System had the strongest association (R=0.58) among the other correlation analysis on Q-sort with the other three indices, which shows the ABO is the closest to the orthodontists' subjective evaluation. The ABO was invented to imitate the examiner's eye.

Private practitioners need to worry about how soon they can finish the case. From the patient's point of view, most of them do not care if the PAR scores, as long as the front teeth look good. As long as teeth are straight and no pathology, they want to get out of braces. It is uncommon that one would keep the braces extra 6 months to achieve PAR score decrease from 2 to 0. Clinical practice is a compromise between time and perfection. What you can do for patients and what you should do for the patients are different but the compromised point of the both orthodontic specialists and no specialists might be close enough to detect the difference by PAR Index.

Our result showed that orthodontic specialists could align posterior teeth better. Unfortunately the majority of the cases from this sample did not achieve the quality the ABO requires to pass phase III of the exam. Although passing the ABO examination is one way to show the orthodontic specialists' superiority, only 23 % of orthodontists are board certified (2001).

Today, a successful orthodontic practice seems to have more to do with business than with orthodontic technique or professional ethics. Many orthodontic continue education courses are focuses on practice management. For example, the number of patient seen per day, patient contact time and finishing cases as soon as possible. Patient's management experts say this as long as front teeth are straight, the cases is finish! The patient can probably not tell the difference between a PAR score of eight out of eleven. Patients will see orthodontists who have more people skills and more video games in the waiting area rather than an orthodontist whose average PAR score are eight. The motivation for orthodontists to provide high quality is internal. Confucius said, " The superior man seeks what is right; the inferior one, what is profitable."

LIMITATONS

Impression technique for the sample casts might work better for non-orthodontic specialists. We found less distortion of study casts, which were treated by non-specialists. Part of this reason was that at the end of the sample correction, we decided to only take the impressions from students who had been treated by non-orthodontic specialists. Our technique for taking the impressions improved by this time, and most of the impressions came out well.

Although the use of occlusal indices is a quick, valid, and accurate method of assessing the dento occlusal aspects of orthodontic treatment results, there are admittedly some limitations. Importantly, changes in facial profile, or cephalometric parameters that reflect the skeletal component of malocclusion are not considered in the quantitative evaluation. Unfortunately, measurement of these variables by valid and reliable methods has not been achieved .The occlusal index may not be sensitive enough to measure the fine

detailing that occurs during the finishing stage of orthodontic cases. Although for the time being, the optimal feasible method for assessing the attainment of desired occlusal outcomes is by the use of occlusal indices.

When scoring models in this study, it was necessary to hand articulate them to a" best fit" since there was no wax bite available for this study. Therefore potential for erroneous results was increased and score would likely higher.

TABLES

TABLE 1. –The PAR score (weighted) Compared by the provider

Components	Orthodontic Specialists	Non-Orthodontists	p-value
Total	11.56±5.60	10.85±5.25	0.39

*Statistically significant p≤0.05

TABLE 2. –The Deflection Index score by provider

	Orthodontic Specialists	Non-Orthodontists	P-value
Total	11.18±7.50	13.0±5.96	0.08

Table 3. – The ABO Objective Grading System Score by provider type

	Orthodontic Specialists	Non-Orthodontists	P-value
Total	26.0.±11.4	29.6±12.8	0.04*
Alignment	5.39±4.37	7.8±5.21	0.0007*
Marginal Ridges	3.92±2.87	4.4±2.87	0.27
Buc-lingul inclination	4.51±4.03	4.18±3.02	0.55
Occlusal contact	4.05±4.34	4.91±5.21	0.22
Occlusal relation	3.11±3.44	3.30±3.48	0.71
Over Jet	4.20±3.96	3.77±3.10	0.43
Interproximal contact	0.78±1.49	1.21±2.77	0.15

Table 4. – The ABO Objective Grading System Score by provider

Score	Total		Orthodontic Specialists		Non-Orthodontists	
	Count	Percentage	Count	Percentage	Count	Percentage
<10	4	2%	4	3%	0	0%
<20	49	25%	37	29%	12	17%
<26	55	28%	33	26%	22	31%
<35	44	22%	29	23%	18	26%
<45	26	13%	18	14%	8	11%
45<	18	9%	8	6%	10	14%
Total	196	100	126	100	70	100

Table 5. —Q-sort X^2 RESULTS

Examiner	X^2	P-Value
1	2.91	0.08
2	3.87	0.04*
3	1.42	0.23
4	0.02	0.88
5	2.1	0.15
6	0.23	0.63
7	0.09	0.76
8	0.77	0.38
9	0.01	0.90

Table 6- Q-sort t-test

	Orthodontic Specialists	Non-Orthodontists	P-value
Total	16.64±4.75	15.4.±5.37	0.22
Average	1.85	1.71	

Table 7—Person Correlation Coefficients for The PAR Index, The Deflection Index, ABO Objective grading system, and Q-sort

	Q-sort	The Deflection Index	The ABO Objective Grading System	The PAR Index
Q-sort	1			
The Deflection Index	-0.47**	1		
The ABO Objective Grading System	-0.58**	0.38**	1	
The PAR Index	-0.56**	0.51**	0.42**	1

(**P< 0.05)

Table 8—Intra Class Correlation Coefficient

Comparison	Reliability Coefficients
PAR	0.96
ABOI	0.94
DI	0.89

APPENDIX 21 Publication Version 2

Orthodontic Care in Cuyahoga County, Ohio: Who provides orthodontic treatment and whom do they treat.

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Abstract

It has been reported that orthodontic services are being provided to a larger segment of the population by an increasing number of providers. The present study surveyed the dental and orthodontic experiences of tenth grade students attending public or private high schools in Cuyahoga County, Ohio. All high schools (n=36) were contacted and 20 agreed to participate. Surveys were distributed in the classroom and data obtained for 2808 students. Approximately 50% of the sample were female with an average age of 15.5 ± 0.8 years. Results of the survey revealed that 84 % (2371/2808) had seen a dentist within the last year and 37% (1047/2808) of the students had received orthodontic treatment by 171 different providers. Of those treated, 73% (764/1047) were treated by a specialist in orthodontics, 11% (118/1047) were treated by a general dentist, 0.5% (7/1047) were treated by a pediatric dentist, with 14% missing or unknown (158/1047). Patients who had seen a dentist within the last year were more likely to have had orthodontic treatment. Only 7% of the untreated students were told by a dental professional that they needed braces compared to 71% of the treated group. Therefore, we conclude that orthodontic specialists provide the majority of orthodontic services in Cuyahoga County and visiting a general dentist positively influences the utilization of orthodontic services.

Introduction

Most orthodontic specialists derive the majority of their income from clinical practice. Therefore, there is considerable interest in the orthodontic community regarding the demographics of clinical care. Very simply, clinicians are interested in knowing who is receiving orthodontic care and what factors might influence the orthodontic treatment decision. Other areas of interest include the percentage of teenagers receiving orthodontic treatment as well as the socio-economic concerns that impact the decision to seek care. In addition to questions pertaining to who is being treated there is also some concern over who is providing orthodontic services. For example, what is the role of the general dentist in recommending and/or providing orthodontic services? Because orthodontics is a specialty in the profession of dentistry, dental practice laws usually allow individuals with a dental degree and a variety of formal and informal training in orthodontics to provide orthodontic services to the dental public.

In the state of Ohio any licensed dentist may provide orthodontic care for his or her patients. However, a general dentist is not allowed to limit their clinical practice to a single specialty area. Because dentistry is most often practiced outside potential secondary regulatory bodies such as hospitals, it is both legal and possible for general dentists to provide comprehensive orthodontic treatment for their patients. Therefore the question arises, what percentage of care is provided by specialists in orthodontics? In other words, are other specialists or general dentists dipping into the orthodontic cookie jar? The perception in the orthodontic community is that general dentists are treating a high percentage of the patients currently receiving orthodontic care. This belief has been supported by reports in the orthodontic literature that indicate that almost half of all the orthodontic treatment provided is done by general dentists with no advanced university training in orthodontics. In addition, anecdotal reports by orthodontic supply companies indicate that almost half their customers are general dentists.

The present study examines the demographic characteristics of orthodontic practice by going directly to the patient. Specifically, this study surveyed tenth grade students attending public or parochial schools in Cuyahoga County, Ohio about their dental and orthodontic experiences.

Materials and Methods

Sample Selection

A cross sectional sample of 2808 tenth graders from 18 public and 2 parochial schools in Cuyahoga county were enrolled in this study. Subjects were recruited by contacting their high school principal. A letter explaining the study was sent to all high school principals in the county. All sixteen of the schools in the city of Cleveland agreed to participate along with 20 schools located in the suburbs surrounding Cleveland. The utilization rate for orthodontic services averaged 7% in the Cleveland city schools compared to over 30% for suburban schools. Because one of the long term goals of this survey was to assess outcome of orthodontic treatment, only two of the 16 Cleveland city schools were

included in the final sample. Of the 20 suburban schools that originally agreed to participate two later declined because they had school levies on the ballot that fall.

Data Collection and Analysis

Data was collected during English class because this was a subject that all students were required to take in the tenth grade. A survey was passed out to all students to assess the dental and orthodontic utilization rates and provide baseline information on orthodontic provider education level. The following information was obtained from the survey.

1. Student's Name
2. Gender
3. Date of birth
4. Phone number
5. Parents occupation
6. Parents education level
7. Name of their dentist
8. Have you ever had orthodontic treatment (braces on your teeth)?
9. Name of their orthodontic treatment provider
10. Date when braces were placed
11. Date when braces were removed
12. Are you wearing a retainer? If No, date you stopped.

Questions #9-12 were only answered by individuals who answered "yes" to question #8.

In addition to these standard survey questions, all students were asked to indicate how they felt about their teeth/smile by placing a mark on a 100 mm likert scale. Students who had received orthodontic treatment were also asked to make a mark on a similar 100 mm likert scale to indicate how they felt about their teeth/smile before braces. The descriptive term "Terrible" was used for the left hand side of the 100mm line and assigned a zero score while the word "Great" was used for the right hand side and assigned a score of 100. Using a millimeter ruler, the distance from the left hand side of the 100 mm line to the student's mark was measured and this value recorded as a continuous variable.

In order to assess the socioeconomic impact on utilization of orthodontic services Hollingshead's two factor index of social position was used. Based on occupation and education level, the students were stratified into five groups, class 1 was the highest and class 5 the lowest socioeconomic group.[1] Means and standard deviations were calculated for all continuous variables and frequencies were tabulated for dichotomous or categorical variables. A two-tailed t-test or analysis of variance was used to test independence of sample means for continuous variables whereas chi-square analysis was used for dichotomous and categorical variables. A p-value ≤ 0.05 was used to assign statistical significance.

Results

Of the 2808 students, 50% were female with a mean age of 15.5 ± 0.8 years. The majority of students were from upper and middle class families. (See figure 1). Eighty four percent (2371/2808) had visited a dentist within the last year. One thousand forty

seven (37%) had received or were presently undergoing orthodontic treatment. The percentage of students who had an orthodontic experience was influenced by a number of factors. The most important factor was the dentist's recommendation. In the total sample of 2808, 42% (n=1180) were told by their dentist that they needed braces. The other 45% (n=1264) were not told they needed braces. The remaining 13% (n=365) did not indicate if they had or had not been told by their dentist that they needed braces. Of the 42% that were told they needed braces by the dentist, 71% followed the dentist's advice and were treated. In contrast, only seven percent of the 45% who were not told they needed braces by their dentist eventually had orthodontic treatment. The decision to seek treatment also varied depending on social status with more affluent students being more likely to have treatment. (See Figures 2-4)

The average rating for all students for their teeth/smile was 69 ± 22 mm on the 100mm Likert scale. Students who had braces rated their smile slightly higher 73 ± 21 compared to students who did not have braces 67 ± 22 but the difference was not statistically significant.

Of the 1047 students who had braces the education level of the orthodontic service provider could be accurately determined for one thousand thirty four. In this subsample, 121 students (12%) were treated by a non-orthodontists and 913 (87%) were treated by a specialist in orthodontics. The percentage of students treated by non-orthodontists ranged from 10% in social class 1, 12% in classes 2 and 3, up to 15% in social class 4. Correspondingly, orthodontists treated between 85-90% of the students in each social class. These percentage differences among social classes were not statistically significant. A total of 171 different orthodontic care providers were listed for these 1034 students. Of these, 90 providers were orthodontists, 78 were general dentists and three were pediatric dentists.

Discussion

The study provides some interesting results with regard to who is being treated orthodontically and whom is providing that care. In contrast to previous reports in the literature, the methods used in this study eliminated bias in reporting by going directly to the consumers of orthodontic services, namely tenth grade high school students. By going to the source, it was not necessary to rely on a third party to estimate utilization of orthodontic services. The results are predictable in some aspects and surprising in others. By surveying more suburban schools than inner city schools we over sampled upper middle class students. Even with this bias, the data supports the popular contention that braces are a quality of life service with status symbol appeal. Two main factors impact on a teenager's decision to have orthodontic treatment. First, if their dentist says that they need braces then 71% of the time they will follow through and have treatment. This finding underscores the importance of the general dentist as the gatekeeper and source of orthodontic patients for the specialist. In the absence of a dental referral, patients in this study sought care only seven percent of the time. Not surprisingly, the individuals who sought care came from the highest socioeconomic class. Therefore, it would be

financially unwise for an orthodontic specialist to alienate his or her general dental colleagues and rely solely on patient referrals.

The second factor that influenced utilization of services was socioeconomic status. Here the data supports the position that orthodontics is an upscale dental service. Utilization steadily increased from the lowest social class (class 5) to the highest social class (class 1). Almost unbelievably, the utilization rates in the some affluent suburban schools approached seventy percent! Since estimates of the percentage of teenagers with dental malocclusion in the United States range from 35-40%, the decision by orthodontists to treat some students at these more affluent schools must be based on different criteria than those used to estimate the prevalence of malocclusion. Our data suggests that if a student's family can afford braces and if their dentist says they need them, then they will be treated. In fact, if the student wants braces and their family can afford them, they might still be treated even without a dental referral.

The data from this study refutes the common belief that 50% of all orthodontic care is provided by non-orthodontists. However, we did find that close to 50% (81/171) of all providers of orthodontic services were non-orthodontists. Therefore, the number of patients treated by each of these non-orthodontists must be small. This finding makes sense if we assume that each non-orthodontist treats their own patients who need orthodontic services but does not receive referrals from other dentists. A logical assumption since a dentist would probably not refer patients to another dentist for a specialty service when a specialist is available. As specialists, we also know that our best referring dentists send between 20 and 30 patients a year to our offices. If one of these referring dentists took a weekend course in orthodontics and decided to treat their own patients, they could start about 25 patients each year. Surveys of orthodontic practices indicate that the average orthodontist treats about 180 cases per year. Doing the math then, if 100 general dentists treat 25 patients per year at the end of the year they will have treated 2500 patients. During the same year, 100 orthodontists treat 180 patients each, for a yearly total of 18,000 patients. At the end of the year a total of 20,500 patients received orthodontic treatment. Of those 20,500 patients, 88% (18,000/20,500) were treated by orthodontists, and 12% (2500/20,500) were treated by general dentists. These theoretical numbers are very close to the actual figures found in the present study and have implications for quality assurance in orthodontic care. A general dentist provideing sub-standard orthodontic care could affect the oral health of 25 patients each year. In stark contrast, an orthodontist providing sub-standard care could affect 180 patients each year. Therefore, the best way to insure that patients receive high quality orthodontic services is to promote excellence within the specialty. Worrying about general dentists providing sub-standard orthodontic care at best wins a battle for 10% of the orthodontic patients. At worst, promotes infighting between dental professionals demeans the profession and undermines the trust patients have in their health care providers.

Conclusions

In summary, approximately 37% of tenth grade students enrolled in the 22 Cuyahoga county high schools participating in this study received orthodontic treatment. The

majority of the care (89%) was provided by specialists in orthodontics. Two major factors influenced utililization of orthodontic services. The first was a determination of the need for care by the family dentist and the second was the family's ability to pay for treatment. The implication of these findings on clinical orthodontic practice is discussed.

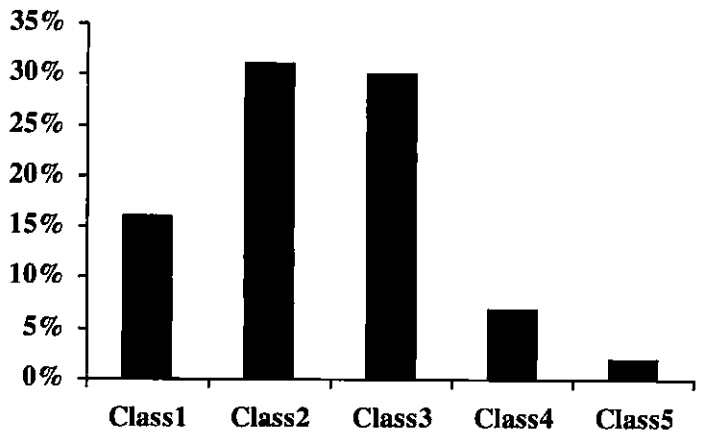


Figure 1 Total sample of 2808 by social class. (class 1 highest social group, class 5 lowest)

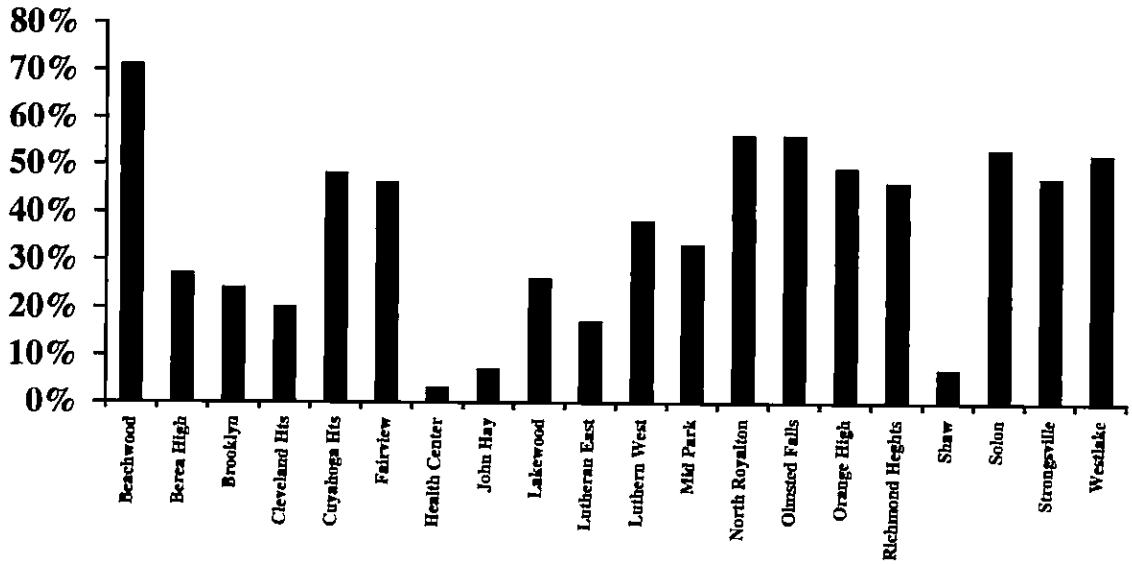


Figure 2. Percentage of students orthodontically treated at each school surveyed (n=1047)

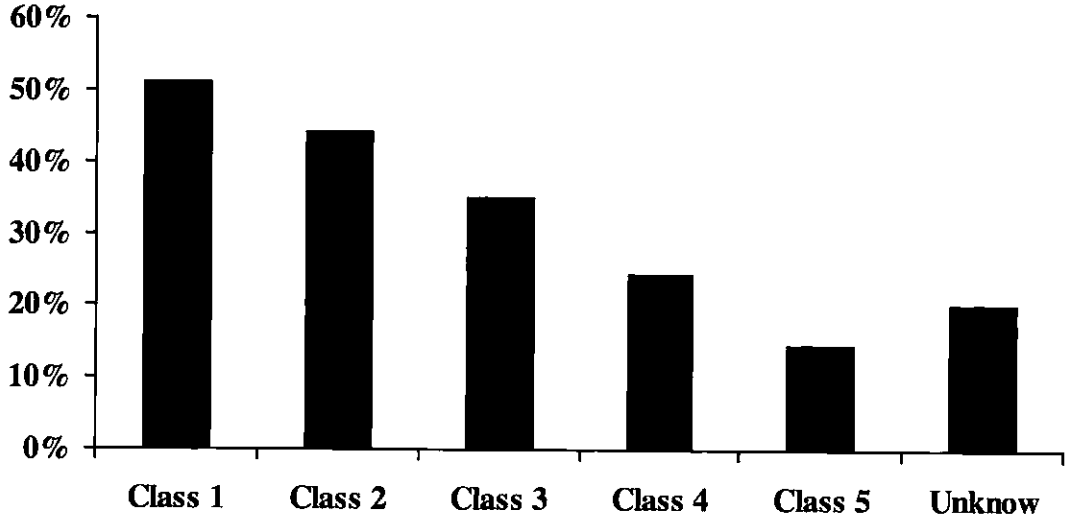
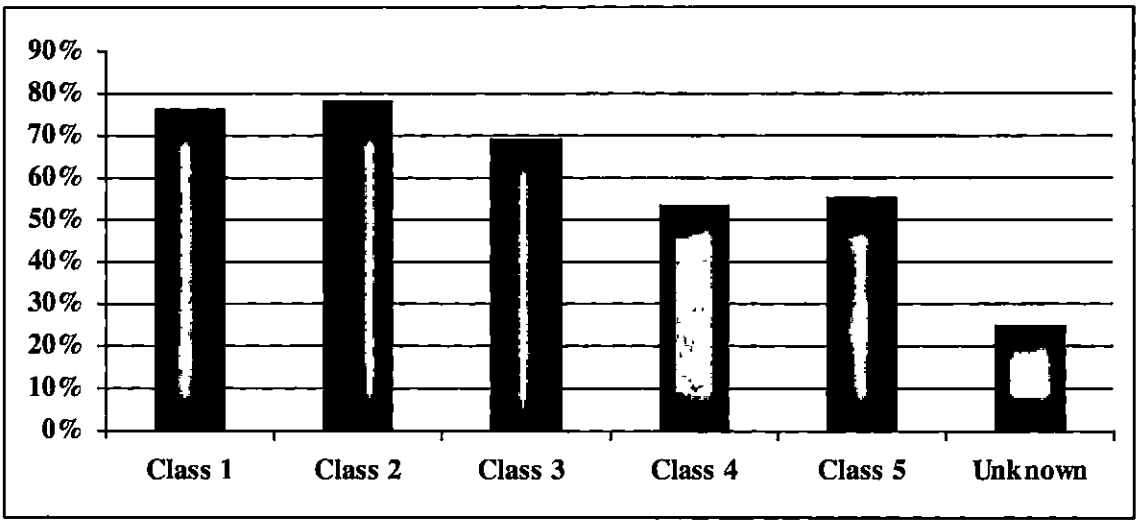


Figure 3. Percentage of students in each social class who had orthodontic treatment (n=1047)

Figure 4. Percentage of students who had orthodontic treatment after being told by their dentist that they needed braces (n=1180)



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