AN ASSESSMENT OF EXTRACTION VERSUS NONEXTRACTION ORTHODONTIC TREATMENT USING THE PEER ASSESSMENT RATING (PAR) INDEX

by

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Abstract

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For almost a hundred years, the extraction of teeth for orthodontic purposes has been at the forefront of controversy in the specialty of orthodontics. This study scored pretreatment and posttreatment study models using the Peer Assessment Rating (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. Cases were chosen from 1,198 consecutively completed cases of a single provider and were all Caucasians under the age of sixteen with no deciduous teeth present at the start of orthodontic treatment.

The results of this study showed that average treatment time for the extraction group was 29.7 months compared to 26.0 months for nonextraction treatment. The extraction group was associated with a significantly worse initial malocclusion, had greater initial maxillary anterior

crowding, and greater initial overjet. Although different at the beginning of treatment, both groups were statistically identical at the end. The results demonstrate that it is possible for an orthodontist to produce equally good dento-occlusal relationships in both extraction and nonextraction cases.

DEDICATION

To my beautiful wife, Emily Ann: Thanks for your endless love, support, and understanding. This would not be possible without you.

To my blessed children, Max, Catherine, and Rachael: You are the joys of my life.

To my parents: Thanks for all the opportunities of life. I hope that I will be as loving to my family as you have always been to me.

To B.A., Philip, and Lara: Thanks for a lifetime of special memories.

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INTRODUCTION

The decision to extract teeth for orthodontic treatment has been one of the most debated subjects throughout the history of the specialty. Edward H. Angle believed that the extraction of teeth for the correction of a malocclusion was intolerable. He wrote,

> "The best balance, the best harmony, the best proportions of the mouth in its relation to the other features requires that there shall be the full complement of teeth, and that each tooth shall be made to occupy its normal position - normal occlusion." (Hahn, 1944)

Angle professed that moving teeth into normal occlusion with orthodontic forces would cause the jaws and associated bones to grow to accomodate the increased size of the dentures. Many orthodontists at the time subscribed to Angle's "new school" of orthodontics, and for years nonextraction orthodontics was practiced.

Because some of Angle's claims were not based on biologic principles, his nonextraction concepts did not go unchallenged. Calvin Case recognized in his practice a large number of bimaxillary protrusion cases, and wrote,

> "Will the gentlemen who have been chosen to discuss this paper tell me how they can possibly correct the facial outlines of these patients by an orthopedic movement of the teeth without extraction, and produce anything like the results which I shall show?" (Case, 1911)

Case also argued that although most malocclusions could be treated without extractions the objective of stability was often not achieved. These views became part of the "Extraction Debate of 1911" between Case and one of Angle's students, Martin Dewey. Although Case's position would ultimately prove correct, Angle's teachings prevailed, and nonextraction treatment remained the standard until the 1940's.

In the 1930's, many practitioners began to observe generalized relapse with nonextraction treatment. This was manifested by procumbencies, arch instability, and a reversion to the original malocclusion. Charles H. Tweed (1944) presented a paper advocating the extraction of all four first bicuspids. Using cephalometric analysis to support his position, Tweed initiated a swing among the orthodontic community toward extraction therapy. The popularity of extraction therapy lasted well into the 1970's.

During the 1980's, the trend toward nonextraction therapy again switched and has persisted until present day. The resurgence of nonextraction therapy is probably the result of many factors including the renewed popularity of early intervention, a greater acceptance of the use of "functional" appliances in the U.S.A., and the change from fully banded appliances to direct bonded brackets. Also, nonextraction treatment modalities have improved with various space gaining procedures such as molar distalization appliances and interproximal stripping. Unfounded association between extraction and the development of TMJ disorders further increased the incidence of nonextraction therapy in the 1980's.

Finally, a consumer-driven market for treatment without extractions combined with a conspicuous lack of experimental evidence to support either position has ultimately kept the extraction-nonextraction treatment debate at the forefront of orthodontics.

In a learned profession such as orthodontics, the decision to extract, or not to extract teeth, should be based on scientific assessments of treatment outcome. A lack of adequate outcome assessment measures has allowed an extraction-nonextraction debate to continue. If neither side has data, the debate is likely to swing to the side with the most persuasive spokesperson. The goal of the present study is to objectively assess the outcome of extraction and nonextraction orthodontic treatment in a sample of one hundred extraction and one hundred nonextraction cases. The Peer Assessment Rating (PAR) Index will be used to measure factors commonly associated with a malocclusion. The PAR Index has been proven to be valid and reliable in assessing the outcome of orthodontic treatment. PAR uses pretreatment and posttreatment study models to determine the success of treatment from the initial malocclusion to the end result. By examining statistical differences in PAR scores between extraction and nonextraction cases, this study will provide part of the answer to the basic clinical question; "Are the teeth straighter and is the occlusion better after extraction or nonextraction therapy?"

REVIEW OF THE LITERATURE

Extraction Frequency

Extraction frequency is defined as a statistical measure describing the number of orthodontic patients having permanent tooth extractions, and is expressed as a percentage of a total treatment sample (Peck and Peck, 1979). There have been many such cited percentages in the orthodontic literature throughout the years. Calvin Case (1911) reported his frequency of extraction as "one case in every twelve or fifteen." By the late 1960's, the extraction frequency of many practitioners was reported as high as 80% (Tweed, 1966). Peck and Peck (1979) compiled a list of previously reported extraction frequencies from 1913 until 1979. These ranged from 6.5% - 83.5%.

Gottlieb et al., (1986) published the results of a comprehensive, nationwide survey of orthodontic diagnosis and treatment procedures. A questionnaire was mailed to all registered orthodontists in the United States. The response rate was 18% (1,486 returned). The mean extraction frequency was 35%. Some form of extraction therapy was used by 95% of the orthodontists. Of this total, 75% of the extraction regimen involved removing maxillary and mandibular first bicuspids.

Weintraub et al., (1989) estimated the extraction frequency of all

licensed orthodontists in Michigan (264) by conducting a telephone survey. The response rate was 90.2%. Subjective estimates given of extraction treatment ranged from 5-87%. The average reported rate was 39% for the entire group. The authors concluded there was a marked difference in the perceived rate of extractions and the actual extraction frequency from an underestimate of 15% to an overestimate of 20%.

O'Connor (1993) mailed a questionnaire to fourteen hundred orthodontists randomly selected from across the United States. The response rate was 58.14% (814 returned). The reported extraction rate was 29.28%. As reported by 26.4% of the respondants, their decision to extract fewer teeth than in the previous five years was influenced by a combination of TMJ and medicolegal concerns. Several retrospective studies including Sadowsky and BeGole (1980), Janson and Hasund (1981), and Sadowsky and Polson (1984) failed to show a correlation between extraction and TMD. O'Connor further stated; "Treatment modalities should be determined by research, not by legal fears or unsubstantiated allegations."

Proffit (1994) reported the frequency of orthodontic extractions at the University of North Carolina from 1953-1993. From the records of approximately six thousand patients, he examined groups of fifty consecutive charts in 1953 and in every fifth year until 1993 (450 total records) to determine extraction rates. Chi-square analysis was then used to test for statistical significance. The results showed four first premolar extractions had a 10% incidence in 1953, peaked at 50% in 1963, and

consistently declined to 10% in 1993. This finding proved to be very significant. The use of maxillary first premolar extractions alone or maxillary first and mandibular second premolar extractions started at 5% in 1953, peaked at 16% in 1968, and dropped back to 8% in 1993. These numbers were not significant. The extraction of other combinations of teeth for orthodontic purposes remained at about 16% for the entire forty-year period. The total extraction frequency for the three categories was 30% in 1953, 76% in 1968, and 28% in 1993. The author concluded changes in orthodontic techniques, concerns about facial esthetics, and concerns about temporomandibular dysfunction have significantly decreased extraction treatment. For the borderline patients, the success of the case is largely dependent on the competency of the orthodontist to place the incisors in the most esthetic position.

Clinical Trials

"Borderline" Extraction Cases

Many studies have been conducted on various aspects of the extraction or nonextraction treatment delimma. According to Paquette et al., (1992),

> "a comparison between extraction and nonextraction treatments can have meaning only for the borderline patient, the patient who is uniquely susceptible to neither treatment and who thus can be treated either way."

The authors utilized a "retrolective - prolective" design (Feinstein, 1985) to compare extraction versus nonextraction treatment in only borderline Class

II edgewise treated patients. All Class II Division 1 patients treated between 1969 and 1980 at Saint Louis University (about 2,500) were contacted. Of this group, 238 agreed to have follow-up records made. Discriminant analysis was used to select the sample of thirthy-three extraction and thirty nonextraction patients from the recall group. The average posttreatment interval was 14.5 years, and the extraction rate of the 238 patients was 57%. The standardized discriminant scores obtained lay within $\pm$ one standard deviation from zero. All these patients were categorized as "borderline" and could theoretically have been treated either way.

The authors then used the same discriminant analysis on this recall sample to determine clinically significant differences. They concluded the extraction decision was based on profile convexity and on maxillary and mandibular anterior protrusion and crowding. Nonextraction treatment produced a more protrusive denture (2 mm) both at the end of treatment and at recall. Seventy-three percent of the extraction group and 57% of the nonextraction group showed less than 3.5 mm of mandibular anterior irregularity. Both overjet and molar correction were derived almost exclusively from differential jaw growth, rather than tooth movement relative to basal bone. Both groups viewed their outcome as an esthetic improvement with the extraction group rating a 63% esthetic improvement after orthodontic treatment and the nonextraction group rating a 53% improvement in facial appearance.

"Clear-Cut" Extraction Cases

Luppanapornlarp and Johnston (1993) used the same 238 Class II patients from Paquette's sample (1992) to study the effects of extraction and nonextraction in "clear-cut" patients. Instead of using the borderline treatment group within ± one standard deviation of zero, these were the patients at the tails of the discriminant-score distribution. Out of 142 patients at the extremes, thirty-three extraction and twenty-nine nonextraction patients were selected. The results showed extraction treatment reduces soft tissue and hard tissue convexity by 2-3 mm where nonextraction treatment has little effect. Relapse was the same in both groups. When growth is finished, clear cut extraction patients have a "fuller" profile than do nonextraction patients. This is due to the significant initial protrusion and crowding of the extraction patients. In nonextraction therapy, maxillary buccal segments are commonly distalized, whereas they tend to come forward with extraction therapy. There is a tendency for the mandible to be displaced mesially during treatment (extraction more than nonextraction). No significant long term differences in signs or symptoms of TMD were noted in either group.

Facial Profile

Drobocky and Smith (1989) studied the soft-tissue profiles of 160 patients who had been treated with the extraction of four first bicuspids. Of this group, fifty-four were male and 106 were female. These patients were obtained from five different groups: Group A patients treated by Charles H.

Tweed; Group B patients treated with the Begg technique from the Kesling-Rocke group; Groups C and D patients from two straight-wire practices; Group E patients with premolars enucleated at an early age. From digitized pretreatment and posttreatment cephalograms, the results showed the nasolabial angle had a mean increase of 5.2° for the entire sample. The upper lip was retruded an average of 3.4 mm and lower lip 3.6 mm from the E-line. Among the five groups, the Tweed group demonstrated the greatest lower lip retraction. Overall, 15% of the cases could be defined as being excessively flat after treatment, and over 80% of patients had soft tissue measurements which showed the profile had improved by orthodontic treatment and did not result in a "dished-in" profile.

Young and Smith (1993) studied the soft tissue profiles of 198 orthodontic patients treated with nonextraction therapy. These results were compared to the data collected by Drobocky and Smith (1989). They concluded that on average nonextraction patients had less facial change than the group of extraction patients. The mean difference between these two groups being approximately six degrees in the nasolabial angle, 1-2 mm in upper lip protrusion, and 2-3 mm in lower lip protrusion. Although average changes were less in nonextraction patients, the range of individual changes in facial profile was almost as great for nonextraction cases as for extraction cases. The difference in techniques (Tweed, Begg, and pretorqued appliances) were much less apparent in nonextraction cases compared to extraction cases. The frequency of undesirable facial changes

associated with nonextraction cases was around 15% which was comparable to the extraction cases.

Bishara et al., (1995) studied the records of forty-four growing Class II Division 1 subjects treated with extraction therapy and forty-seven subjects treated without extractions. These were compared to thirty-five untreated Class I subjects. All were from the Iowa Longitudinal Facial Growth Study and were matched for age and sex. Eighteen hard tissue and six soft tissue landmarks were identified on lateral cephalograms. Comparisons between both Class II Division 1 groups and the untreated Class I group indicated that the Class II Division 1 malocclusion presented with a significantly more convex profile. For male subjects in the extraction group, the upper and lower lips were more protrusive relative to Ricketts' esthetic plane. In females, only the lower lip was more protrusive. This indicates in this group of patients, lip protrusion was an important parameter on which to base the extraction decision. At the end of a five-year observation period, the extraction group in both male and female groups had more retrusive lips than the corresponding normal group. The nonextraction subjects had a tendency for the lips to be more protrusive.

Overjet / Overbite

Little et al., (1981) studied sixty-five cases of first premolar extraction patients that had undergone routine edgewise orthodontic therapy. Using dial calipers, calibrated to a hundredth of a millimeter, measurements were taken on pretreatment and posttreatment models (at least ten years after

complete removal of all retainer devices). Prior to treatment, overjet was greatest in Class II Division 1 cases (X= 8.96 ± 0.47 mm). This differed significantly from Class I cases (X= 4.74 ± 0.35 mm) and from Class II Division 2 cases (X= 4.96 ± 0.78 mm). During treatment, overjet decreased significantly in all three groups. Significant decreases were noted in net overjet between pretreatment and posttreatment measurements in all three categories. Relapse occurred more often in Class II Division 1 cases rather than Class I or Class II Division 2 cases.

Overbite was greatest in the Class II Division 2 patients (X= 5.74 ± 0.67 mm). This was significantly different from Class I (X= 3.48 ± 0.27 mm) and Class II Division 1 patients (X= 3.46 ± 0.38 mm). The mean overbite for all patients decreased significantly during the period of active treatment. Class II Division 2 patients showed the greatest treatment decrease in overbite (X= -3.09± 0.84 mm). In contrast, there was a significant increase in overbite for all cases during the postretention period (X= 0.76 ± 0.15 mm,P<0.001). There were no significant differences between the three classes of malocclusion and the amount of overbite relapse. The authors concluded that overbite and overjet treatment and relapse changes were not reliable in predicting incisor alignment stability

Shields et at., (1985) studied the relationship between overjet and overbite as they related to mandibular anterior crowding in premolar extraction cases. Fifty-four cases of four first premolar extractions from the University of Washington were selected. Of this group, 46.3% were Class I,

44.4% were Class II Division 1, and 9.3% were Class II Division 2. Dial calipers were used to measure various factors including overbite and overjet. Also, cephalometric superimpositions of pretreatment, posttreatment, and post-retention radiographs were analyzed. The results showed the maxillary incisors uprighted 9.6° (I - Na). There was only a slight tendency for rebound in the direction from which the incisors came: however; no clinically significant relapse was apparent. Also, no pretreatment or posttreatment cephalometric variable predicted postretention relapse. In regard to overbite, the authors found in many cases, the incisors were intruded during treatment. Following treatment, the incisors extruded. A discriminant model based on a combination of pretreatment and posttreatment skeletal variables was found to be able to predict patients that could expect significant postretention bite deepening ($\geq$ 4 mm). These patients tended to have lower mandibular plane angles and higher SNA and SNB angles. A pretreatment Class II molar relationship was a clinically significant predictor of posttreatment bite deepening, whereas, a pretreatment Class I molar relationship did not show any association with posttreatment overbite.

Bishara et al., (1994) studied the effects of extraction and nonextraction orthodontic treatment on growing Class II Division 1 subjects over a five-year period. A matched sample of thirty-five Class I untreated subjects was chosen in comparison. In male subjects, the initial Class II group had a significantly larger overbite and overjet when compared to the Class I group.

The female group was only statistically significant with regard to overjet. At the end of the five-year period, extraction and nonextraction treated subjects (both male and female) had similar reductions in overjet and overbite when compared to the Class I sample and no statistically significant differences were noted.

Parker et al., (1995) conducted a study of skeletal and dental changes associated with the treatment of deep bite malocclusions. On the basis of a presenting overbite at least 70%, 132 patients (sixty-one Class I, 27 Class II Division 1, and forty-four Class II Division 2) were chosen. These cases were divided into six different groups according to the different treatment mechanics that were used. There were no statistical differences in the results of the six treatments. On average, the Class I group had a decrease of the overbite of 4.07 mm, the Class II Division 1 had a decrease of 5.79 mm, and the Class II Division 2 decreased 4.79 mm. For each Angle's classification group, an analysis of variance was run for comparing extraction versus nonextraction treatment. The authors concluded the extraction of teeth did have a significant effect during treatment in all groups but was much more evident in Class I patients. In the nonextraction sample, the average decrease in overbite was 3.79 mm. In the extraction sample, the average decrease was 4.77 mm. Overall, the incisors were proclined less and the molars moved more mesially in the extraction group when compared to the nonextraction sample.

Stability

Over the years, orthodontists have considered the mandibular arch as being the limiting factor for treatment and have viewed it as the primary consideration for diagnosis. Mandibular anterior alignment should remain long-term for the case to have achieved "stability." However, numerous studies have shown that mandibular anterior alignment is difficult to maintain regardless of the extraction - nonextraction treatment decision.

Several authors (Riedel,1960; Bishara et al., 1973; Glenn et al., 1987) showed that the mandibular intercanine width could not be permanently expanded. Little et al., (1981) concluded long-term (> ten years post-retention) response to mandibular anterior alignment was unpredictable. Variables such as initial crowding, age, sex, Angle's classification, etc., were not helpful in predicting outcome. He found in two-thirds of the cases studied there was an unacceptable amount of crowding (> 3.5 mm). Little, (1990) published a review article on stability and relapse of the mandibular arch. Over six hundred sets of patient records from the University of Washington were collected over more than thirty-five years. The results showed that arch length and arch width decreased in all groups following retention because of what appears to be a normal, physiologic process. He concluded there was considerable patient variability and the degree of crowding is unpredictable. Only 30% of patients exhibited success in maintaining satisfactory alignment. Third molar presence or absence has little effect on the occurrence of relapse.

Rossouw et al., (1993) evaluated the mandibular anterior dentition of extraction and nonextraction treated subjects to assess the long-term stability of the mandibular incisors. The mean postretention follow-up was seven years. The authors found the mandibular intercanine width tended to decrease beyond the initial width and that a decrease in arch length post-retention was the major cause of mandibular incisor instability.

Vertical Dimension

Drobocky and Smith (1989) in their study of soft-tissue profiles noted an increase in vertical dimension after the extraction of four bicuspids. Their results showed that in five different treatment modalities, all groups exhibited an increase in vertical facial height (Sn-Me). The mean increase for the sample was 2.78 mm. The straight-wire patients showed a greater increase than either the Tweed or Begg groups. Young and Smith (1993) also investigated the effects of facial profiles of patients treated by nonextraction therapy. They showed an increase in lower facial height with an average 4.17 mm increase for the entire sample. Finally, results on the long term effects of Class II Division 1 patients in both "borderline" (Paquette et al, 1992) and "clear-cut" (Luppanapornlarp and Johnston, 1993) extraction cases clearly shows an increase in vertical dimension (N-Me).

Chua et al., (1993) further studied the effects of extraction and nonextraction orthodontic treatment on lower facial height (ANS-Me). Eighty-seven Class I cases (forty-five extraction and forty-two nonextraction) and eighty-seven Class II cases (forty extraction and forty-seven

nonextraction) were included in the study. Growth was factored out so that the only variable to account for an increase in lower facial height would be orthodontic treatment. The results showed that nonextraction treatment in both Class I and Class II subjects significantly increased the lower facial height (ANS-Me). Conversely, extraction treatment was not associated with any changes in lower facial height.

Staggers (1994) investigated the validity of the claim that extraction of first premolars causes a decrease in the vertical dimension of occlusion which leads to TMJ disorders. Forty-five nonextraction and thirty-eight first premolar extraction patients were obtained. All were skeletal and dental Class I. The pretreatment and posttreatment lateral cephalograms were traced and digitized. Orthodontic treatment, both extraction and nonextraction resulted in a slight increase in mandibular plane angle, extrusion of maxillary and mandibular first molars, and an increase in anterior face height (N-Me). Only seven out of eighty-three (three extraction, four nonextraction) had a decrease in anterior facial height during treatment.

Condylar Position

Gianelly et al., (1991) studied the effects of extraction and nonextraction treatment on condylar position. A study sample of 111 patients whose treatment records included treatment corrected tomograms of right and left condyles were used (seventy-nine nonextraction, thirty-two extraction). The results showed no statistically significant differences between the two groups. The condyles of both the extraction and

nonextraction patients were effectively in the same position before and after treatment. Nine patients showed unilateral distal displacement of the mandibular condyles (six nonextraction, three extraction). The authors concluded that distal repositioning of the condyles was a distinctly rare event, occurring in less than 5% of the time and was not clinically significant.

Luecke and Johnston (1992) investigated forty-two edgewise treated Class II Division 1 malocclusions to determine the effect of maxillary first bicuspid extraction on mandibular position. Regional superimposition of the cranial base, the maxilla, and the mandible were included as well as D point (the center of the symphysis), C point (the center of the condyle), and condylion (the most posterosuperior point on the surface of the condyle). In 70% of the cases, a net forward displacement of the mandible occurred as evidenced by a positive change at C and D points. Thirteen out of forty-two (30%) showed evidence of distal displacement in condylar position. The authors concluded condylar remodeling stabilized the spatial position of the condyle, and the only true method of assessing changes in condylar position is by implant studies, not by serial radiographs. Paquette et al., (1992) also concluded in their "borderline" study that there was 3 mm forward translation of the mandible at Menton and 2 mm at the condyle. Similarly, Luppananpornlarp and Johnston (1993) found the condyle did not move distally but produced a forward displacement.

Beattie et al., (1994) used Paquette's "borderline" sample of Class II Division 1 extraction and nonextraction patients to compare the long-term

functional status of the temporomandibular joints and the neck musculature. The mean posttreatment interval was 14.5 years. The patients were assessed by the sixty-two items of the Craniomandibular Index (CMI) of Fricton and Schiffman (1986) to evaluate the joints and muscle pain. The results showed no significant differences between the extraction and the nonextraction group. According to Fricton and Schiffman, a patient with an internal derangement or Mysofacial Pain Dysfunction (MPD) would have an average of fifteen to twenty positive CMI responses. The worst case in Beattie's sample had only nine positive CMI responses.

Many opinions have been published in the literature as to the origin and treatment of temporomandibular disorders, but little scientific data has been presented to back up these opinions. Reynders (1990) published a review of ninety-one TMJ articles appearing in the dental literature from 1966-1988. Of these published articles, only six were reports of clinical studies. The other eighty-five were author viewpoints and case reports.

Since 1988, more clinical studies have been published in the refereed literature. Sadowsky (1992) published a review of the TMJ literature from 1988-1991. The conclusions from these udies show that temporomandibular disorders have a multifactorial etiology and little correlation exists between orthodontic treatment and the development of TMJ dysfunction.

Outcomes Assessment

Occlusal Indices

For many years, the extraction versus nonextraction debate has been waged on several fronts. Extractionists have argued nonextraction therapy produces instability and procumbent dentures. Nonextractionists counter these arguments with claims that extraction treatment creates "dished-in profiles" and unnecessary loss of dental units. Various studies have been undertaken which support the validity of both positions. Since an orthodontist specializes in correcting malocclusions by carefully aligning teeth into proper functional, esthetic, and stable occlusions, one way of assessing treatment outcome is to simply grade the orthodontic movement of teeth in extraction and nonextraction cases.

In recent years, assessing the outcome of treatment has become increasingly important in both the medical and dental professions. To reduce subjectivity in reporting outcomes, occlusal indices have been developed in orthodontics that describe the various aspects related to a malocclusion. By using occlusal indices to score finished extraction and nonextraction cases and by subjecting these results to statistical analysis, significant clinical differences might be identified between these two treatment strategies. These differences could then be used as guidelines for diagnosis and treatment planning of orthodontic cases.

Indices have been developed over the years to define, diagnose, and assess the extent of malocclusions. The most commonly used orthodontic

index is Angle's classification of malocclusion (Angle, 1899). Other indices that have been used include Draker's Handicapping labio-lingual deviations (HLD) 1960, Grainger's Orthodontic Treatment Priority Index (TPI) 1967, Salzman's Handicapping malocclusion assessment to establish treatment priority 1968, and Summers' Occlusal Index 1971. These were developed to assess need for orthodontic treatment. In socialized health care, these indices may provide an avenue for distributing funds to individuals with the greatest treatment need.

Development of the PAR Index

In 1984, the Department of Health and Social Security (DHSS) in Great Britain issued a report on unnecessary dental treatment being done in England. A board review of these findings known as the "Schanschieff Report" issued several recommendations to improve the country's dental care. Among these recommendations were that the DHSS develop an index of occlusion for use by the Dental Practice Board in assessing orthodontic treatment need and treatment outcome. 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. 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 (Richmond et al., 1993).

The PAR Index was developed specifically to assess the outcome of orthodontic treatment. The assessment of completed orthodontic care by

peer review is necessary to maintain a high quality standard in the profession. However due to the subjective variability of individual practitioners, it is difficult to achieve a standard evaluation. For research purposes, an objective and precise system of grading was needed (Richmond et al., 1994).

In 1987, a group of ten experienced orthodontists from the British Orthodontists Working Party met in a series of six meetings to formulate an index of treatment outcome. Over two hundred dental casts were examined and discussed until the components of a new index were established. The PAR Index assigns a score for each occlusal trait of a malocclusion. The individual scores are multiplied by a weighting factor and the weighted values are added to obtain a final PAR score. A final score of zero would represent perfect alignment. Generally, a final score of ten or less indicates an acceptable alignment and occlusion. Higher pretreatment scores indicate a more severe malocclusion. Although there is no maximum initial score, these rarely exceed 50. This final score represents the amount the case deviates from normal occlusion - "all anatomical contact points being adjacent, with a good intercuspal mesh between upper and lower buccal teeth, nonexcessive overjet and overbite" (Richmond et al., 1992a). The index is applied to both pretreatment and posttreatment study casts. The difference between the initial score and the final score is one measure of treatment outcome (Richmond et al., 1994).

Properties of an Occlusal Index

Several authors have described properties that an index should possess. DeGuzman et al., (1995) list the basic requirements of any index to be validity and reliability. Validity means the index measures that which it professes to measure. Reliability is the ability of an index to reproduce the original scores when the subject is re-examined by the same or a different examiner. An index should be easy to learn and apply. It should also be sensitive and acceptable to the profession and the public. Finally, an index should be objective and amenable to statistical analysis.

Validity

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 scored 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.

DeGuzman et al., (1995) validated the PAR Index using a group of orthodontists in the United States. Two hundred sets of study casts of

various malocclusions from the University of Pittsburgh School of Dental Medicine were scored by two examiners using the PAR Index. A group of 11 orthodontists from Western Pennsylvania rated these casts on the basis of: 1) Degree of deviation from ideal occlusion; 2) The anticipated difficulty of treatment; and 3) Treatment duration. Statistical analyses with correlation coefficients and multiple regression models were used to establish a set of weightings for the PAR Index consistent with standard of treatment ideals of orthodontists in the United States.

When the PAR Index was first developed, there were eleven defined components (Richmond et al, 1992a). 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 the severity of a malocclusion. Thus, four previously defined components were eliminated, reducing the number of scored components to seven (O'Brien,1995). In DeGuzman's study, they also concluded there was no predictive effect in the difficulty of treatment of lower incisor crowding and therefore, this component did not receive a weighting. Presently, the PAR Index is composed of six scored segments and only five weighted components: 1) Upper anterior segment crowding (UAS); 2) Right and Left Buccal segment occlusion (RBO, LBO); 3) Overjet (OJ); 4) Overbite (OB); 5) Midline deviation (MID).

Buchanan et al., (1993) compared the validity between the PAR Index and Summers' Occlusal Index (OI) in assessing treatment outcome. A group

of eighty pretreatment and posttreatment models were used. Correlation coefficients used to assess validity showed the PAR Index to have a correlation of r = 0.85 and the OI to have a correlation of r = 0.94. To test for bias, a two-tailed t-test was applied between the two values. The t-test showed no significant difference between the two indices (P>0.05). Therefore, the authors concluded the PAR Index was as valid as Summer's Occlusal Index.

Reliability

Richmond et al., (1992a) reported the PAR Index has excellent intra-examiner and interexaminer agreement. Four trained examiners examined thirty-eight cases randomly selected from a sample of two thousand cases. Intraexaminer and interexaminer agreement was checked using the Intraclass correlation coefficient of Reliability (Fleiss et al., 1979). If the lower confidence limit of the correlation is greater than r = 0.75, this suggests the results can be relied upon with confidence. In this study, the intraexaminer reliability was r = 0.95 and the interexaminer reliability was r = 0.91.

Buchanan et al., (1993) also compared the reliability between the PAR Index and Summers' Occlusal Index. The same thirty-eight models from the study conducted by Richmond (1990) were used. In this study, reliability was evaluated with an intraclass correlation coefficient. The results showed the reliability for the total scores for the PAR Index to be r = 0.96 and the OI to be r = 0.97. Thus, the authors concluded the PAR Index is as reliable in assessing treatment outcome as Summers' Occlusal Index.

Assessing Improvement Using the PAR Index

The objective of the PAR Index is to measure the outcome of orthodontic treatment based on the scoring of pretreatment and post-treatment casts. There are two ways of assessing improvement using the PAR Index:

1. The numerical reduction in the weighted PAR score
2. The percentage reduction in the weighted PAR score.

The amount of improvement possible as determined by the numerical reduction in the weighted PAR score is limited by the initial pretreatment PAR score. If this initial score is high, there can be a significant degree of improvement. On the other hand, if the initial score is low, the maximum degree of improvement will automatically be much less. The percentage reduction in the weighted PAR score demonstrates the success of treatment.

> "Thus, a change in PAR score from 50 to 10 (a reduction of 40) and a change from 15 to 3 (a reduction of 12) both produce an 80% reduction, but a much greater numerical improvement in PAR has been achieved in the first instance" (Richmond et al., 1992b).

Richmond et al., (1992b) also determined a method for relating numerically the difference in pretreatment and posttreatment PAR scores. The panel of seventy-four examiners graded 128 pairs of dental casts. They recorded the degree of improvement on a 9-point scale from 0 (markedly worse) to 8 (greatly improved). The median scores derived were placed into three groups: "worse or no different", "improved", or "greatly improved." Discriminant analysis was used to creat a linear separation between these

three classes. It was determined statistically that for a case to be classified as "greatly improved", the numerical reduction in PAR score has to drop by 22 points. To be classified as "improved", the percent reduction in PAR score must be at least 30%. To be placed into the "worse or no different" group, there has to be less than 30% improvement. These groupings are based on the British weighting system only and cannot be applied to the U.S. (Pittsburgh) validation weightings.

A final criteria established was that a high standard of treatment is achieved when the proportion of total cases falling in the "worse or no different" category is less than 5%, and the mean percentage reduction in weighted PAR score is greater than 70% (Richmond et al., 1992b). The percentage of "greatly improved" cases should also be greater than 40%. If these goals are met, this suggests that the practitioner is treating a high percentage of patients with an obvious need for treatment to a high standard.

DeGuzman et al., (1995) determined similar criteria for assessing improvement during the U.S. (Pittsburgh) validation study. After orthodontic treatment, the authors concluded that a case with a pretreatment PAR score of greater than 40 was a severe malocclusion. Following treatment, a percentage change in PAR score of 65% reflected a great improvement in occlusal factors.

Outcome Studies Using PAR

Kerr and Buchanan (1993) studied the treatment success of 150

consecutively completed patients in the undergraduate clinic of the Glasgow Dental Hospital and School. The orthodontic treatment consisted entirely of removable appliances. By using the PAR Index to grade pretreatment and posttreatment casts, they found that 89% were classified as "improved" or "greatly improved." Eleven percent were listed as "worse or no different." The mean percentage reduction of all cases was 52%.

Richmond et al., (1993) investigated training dental and non-dental personnel in the use of the PAR Index. At the Dental Practice Board of England and Wales, five dental advisers (three orthodontists and two general dentists) and four administrative officers were trained in the use of the PAR Index over a fifty hour period. The results showed all the dental advisers and two of the administrative officers were calibrated in the use of the index. This indicated that it was possible to train non-dental staff in the use of the PAR Index.

Fox (1993) used the PAR Index to personally audit his first hundred consecutively started orthodontic cases. His results revealed 41% were classified "greatly improved", 47% were "improved", and 12% were "worse or no different." He pointed out that even though some cases were classified as "worse or no different" , beneficial occlusal changes had occurred in some of these. He felt the PAR Index may not be sensitive enough to limited treatment goals.

Richmond (1993) also used the PAR Index as a method to personally grade his own treatment outcomes. Fifty-one consecutively treated patients

from the Bolton General Hospital were obtained. The mean percentage reduction in PAR score was 74%. Also, 53% were "greatly improved", 39% were "improved", and 8% were "worse or no different ." The author recommended all orthodontists to assess their own standard of care by a personal audit every two to three years.

O'Brien et al., (1993) studied the treatment outcome of 1630 patients in seventeen hospital based orthodontic programs by using the PAR Index. The mean pretreatment PAR scores for all 1630 casts was 28.8, and the mean posttreatment score was 8.27. This resulted in a mean percentage reduction of 67.62%. In general, they determined the hospital-based programs delivered treatment of a high standard. The effectiveness of treatment was most effected by the experience of the provider and the choice of treatment methods, either fixed (two arch versus one arch) or removable. They also concluded that the PAR Index has sufficient sensitivity to detect differences in the treatment outcomes between several orthodontic departments. O'Brien and Weyant (1993) used this same sample to evaluate the number of visits required to complete orthodontic treatment. They determined that the number of visits required to complete treatment was directly proportional to the severity of the initial malocclusion and did not relate to the experience of the operator.

Stephens et al., (1993) used the PAR Index to analyze the treatment outcome of orthodontic cases completed by general dentists in England and Wales. Forty randomly selected cases from a sample of 1010 cases

submitted to the Dental Estimates Board from 1987-1988 were scored. The mean percentage reduction in PAR score was 37.9%. Only 23% were "greatly improved". Also, 38% were classified as "worse or no different". They concluded that indices can be used to assess treatment standards, but will not be able to provide the cause for treatment failure.

Richmond and Andrews (1993) studied the orthodontic treatment outcome of a random sample of Norwegian orthodontists. Six orthodontists selected 220 cases. The mean percentage reduction in PAR score was 78%. Only 5% of the cases were classified as "worse or no different". This figure was significantly better than that reported percentage reduction in Britain as 55% (Richmond et al., 1992b). The authors stated that Norway is "unique in that orthodontic treatment is almost entirely delivered by registered specialist orthodontists." They concluded in this study that indices can be used to identify differences in individual as well as different countries' healthcare systems.

Vayda et al., (1994) used the PAR Index to compare the difference in treatment outcomes between Class I and Class II malocclusions. The study sample chosen consisted of 176 Class I and 311 Class II cases treated in the orthodontic clinic at the University of Pittsburgh. The mean initial PAR scores for Class I and Class II malocclusions were 27.6 and 49.1 respectively. Corresponding values posttreatment were 7.8 for Class I and 11.9 for Class II cases. The percentage reduction in PAR scores were 68.6% and 74.4%. It was concluded that the mean initial malocclusion for

Class II was significantly greater, as well as, the percentage reduction in PAR scores was greater for Class II. Vig et al., (1994) in another study utilized the same Class I and Class II sample from the University of Pittsburgh to evaluate treatment duration. The authors found patient compliance and cooperation reduces treatment time for Class II but does not effect Class I. Also, more experienced clinicians reduce Class II treatment duration but do not effect Class I treatment time.

Afsharpanah et al., (1995) applied the PAR Index to an untreated sample to assess the effects of normal growth and development on the improvement of a malocclusion. One hundred subjects were selected from the Bolton-Brush Growth Study in Cleveland, Ohio. The selection criteria were that the subjects were actively growing, had a full permanent dentition, and had not had any orthodontic treatment. The average age for the subjects at time one (T-1) was 12.4 years;the average age at time two (T-2) was 14.4 years. The mean PAR score at T-1 was 18.7 and at T-2 was 16.8. The results showed no subjects were classified as "greatly improved", sixteen were "improved", and eighty-four were "worse or no different." The authors concluded that the initial malocclusion only improved in 16% of this sample through normal growth and development.

Feghali et al., (1995) assessed the outcome of orthodontic treatment in a graduate orthodontic clinic using the PAR Index. The most recent 100 consecutively completed cases in the graduate orthodontic clinic at Case Western Reserve University (CWRU) in Cleveland, Ohio, were studied. The

mean pretreatment age was 13.0 years, and the average treatment duration was 32.7 months. The average pretreatment PAR score was 34.0, and the average posttreatment score was 11.0. From this group, 55% were defined as "greatly improved", 41% were "improved", and only 4% were classified as "worse or no different." The study showed that the graduate orthodontic clinic at CWRU was treating patients to a high standard.

O'Brien et al., (1995) obtained data on 250 Class II Division 1 patients treated in the Orthodontic Department of the University of Pittsburgh from 1977-1989. All patients were aged 11-14 years at the start of treatment and had at least a 5 mm overjet. The purpose of this study was to measure the outcome of treatment as it related to treatment duration. Multiple regression techniques were used to uncover correlations between treatment time and the following factors: 1) Pretreatment PAR score; 2) The number of treatment phases; 3) The percentage of patient appointments made; 4) The number of appliance breakages; and 5) Whether, or not, the patient had extractions. The results showed that the only variable that influenced the percentage PAR score change was the pretreatment PAR score. This compares favorably with the findings of Berg and Fredlund (1981). They examined the treatment results of 264 consecutively completed cases using a Norwegian treatment priority index. The cases were analyzed on whether or not they had achieved "textbook" normal occlusion. This was found in less than 50% of the cases. The authors concluded that the greatest reduction in score occurred in cases that displayed high initial pretreatment scores.

Despite the numerous cited studies regarding extraction and nonextraction orthodontic treatment, little research has been conducted in actually grading how well an orthodontists moves teeth into proper, functional positions. The Peer Assessment Rating (PAR) Index was developed to provide an objective assessment of the dento-occlusal relationships of the teeth after orthodontic treatment. By scoring cases treated with the extraction of four bicuspids and cases treated without the removal of permanent teeth, this study will use the PAR Index to statistically analyze the outcome of extraction and nonextraction therapy. In this manner, clinically relevant data will be produced to assist orthodontists in achieving the ultimate outcome of orthodontic treatment; an esthetic, functional, and stable dentition.

METHODS AND MATERIALS

From a population of 1,198 consecutively completed orthodontic cases of a single provider (Dr. Mark G. Hans, Berea, OH), the principal investigator (JKH) reviewed the study models and patient records to establish a study sample of two hundred; one hundred cases treated with the extraction of four bicuspids and one hundred cases treated without tooth removal. Beginning at case number one, the pretreatment and posttreatment study models from this population were evaluated to determine if they met the following criteria:

1. Completed orthodontic treatment with either extraction of four bicuspids or without extraction of permanent teeth
2. Pretreatment study models with no deciduous teeth present

Only adult dentition cases were selected because the use of the PAR Index in scoring mixed dentition cases has been questioned by several authors (Kerr and Buchanan, 1993; Fox, 1993). After initial screening of the pretreatment and posttreatment dental casts, treatment records were reviewed to determine the age of the patient at the start of treatment. Only patients below the age of sixteen were chosen. This was done to eliminate nongrowing or slow-growing subjects from the study sample. The following data was abstacted from the treatment records of the selected patients:

1. Age at the start of treatment (years)
2. Race
3. Gender
4. Total treatment duration (months)
5. Occupation of the parent or guardian responsible for the orthodontic care

The first one hundred extraction and one hundred nonextraction cases that met the inclusion criteria were chosen for the study. All the orthodontic cases were completed by the provider (MGH) using O.18 pretorqued, preangulated Roth prescription brackets ("A" - Company, San Diego, CA). The pretreatment and posttreatment study models were first classified as extraction or nonextraction and then categorized by Angle's classification. The study models were then scored by the principal investigator (JKH) using the PAR Index (Richmond et al., 1992a). The investigator has been calibrated in the use of the PAR Index by Dr. Kevin O'Brien, Senior Lecturer in Orthodontics, Manchester, England. The following description of the PAR Index was taken from the text, An Introduction to Occlusal Indices (Richmond et al., 1994) and is reprinted here with permission from the author.

> The PAR index is applied to an individual's pre- and post-treatment study casts. Scores are assigned to the various occlusal traits that make up the malocclusion. The individual scores are summed to obtain a total that represents the degree a case deviates from normal alignment and occlusion. The difference between the pre- and post-treatment PAR scores indicates the degree of improvement as a result of orthodontic intervention. There are 5 components of the PAR Index (TABLE 1).

TABLE 1.--Components of the PAR Index

1. Upper Anterior Segment Displacement (UAS)
2. Right and Left Buccal Occlusion (RBO, LBO)
3. Overjet (OJ)
4. Overbite (OB)
5. Midline deviation (MID)

Upper Anterior Segment (UAS)

A score is recorded for the upper anterior segment alignment. The recording zone is from the mesial contact point of the canine on one side to the mesial contact point of the canine on the opposite side. The features recorded are crowding, spacing, and impacted teeth (TABLE 2). Contact point displacement is recorded as the shortest distance between the contact points of adjacent teeth parallel to the occlusal plane. The greater the contact point displacement the greater the score.

Impactions of incisors and canines are recorded. A tooth is regarded as impacted if the space between the two adjacent teeth is less than or equal to 4 mm. Both ectopic incisors and canines are recorded in the anterior segment. Scores for the contact point displacements and impacted/ectopic teeth are summed to give an overall score for each anterior segment.

Buccal Occlusion (RBO, LBO)

The buccal occlusion is recorded for both right and left sides. The fit of the teeth is scored in all three planes of space. The recording zone is from the canine to the last molar, either first, second, or third. All features are recorded when the teeth are in occlusion, The antero-posterior, vertical, and transverse scores are summed for each buccal segment (TABLE 3).

TABLE 2.--Upper Anterior Segment Displacement (UAS)

Score	Displacement
0	0 - 1 mm
1	1.1 - 2 mm
2	2.1 - 4 mm
3	4.1 - 8 mm
4	greater than 8 mm
5	impacted teeth

TABLE 3.--Buccal Occlusion Assessments (RBO, LBO)

Antero-posterior score	Vertical score	Transverse score
0 Good interdigitation Class I, II, or III	0 No open bite	0 No crossbite
1 Less than half unit from full interdigitaion	1 Lateral open bite on at least 2 teeth > 2 mm	1 Crossbite tendency
2 Half a unit (cusp to cusp)		2 Single tooth in crossbite
		3 More than one tooth in crossbite
		4 More than one tooth in scissors bite

Overjet (OJ)

Positive overjets as well as anterior teeth in crossbite are recorded (TABLE 4). The recording zone includes all incisor teeth. The most prominent incisor overjet is identified and the overjet is recorded to the labial aspect of the incisal edge. When recording the overjet, the ruler is held parallel to the occlusal plane and radial to the line of the arch. It is not uncommon to see two upper laterals in crossbite as well as an increased overjet on the central incisors. In this situation, if the overjet was 4 mm, the score would be 3 for the crossbite and 1 for the positive overjet, 4 in total.

Overbite (OB)

Records the worst vertical overlap or open bite of any of the four incisors. Overbite is recorded in relation to the coverage of the lower incisors or the degree of open bite (TABLE 5).

Midline Deviation (MID)

The difference between the upper and lower dental midlines is recorded in relation to the lower dental midline (TABLE 6).

Weightings

Various degrees of importance have been attached to the 5 components of the PAR Index. There are currently two weighting systems; the original weighting validated to reflect British orthodontic opinion (Richmond et al., 1992), and the other established by American orthodontists (DeGuzman et al., 1995)(TABLE 7).

The PAR Ruler

A ruler has been designed to make measurement easier. The information on the ruler summarizes the index and allows quick assessments (Appendix 1).

TABLE 4.--Overjet Assessment (OJ)

Overjet	Anterior Crossbites
score 0 0 - 3 mm	score 0 No crossbite
1 3.1 - 5 mm	1 one or more teeth edge/edge
2 5.1 - 7 mm	2 one single tooth in crossbite
3 7.1 - 9 mm	3 two teeth in crossbite
4 greater than 9 mm	4 more than two teeth in crossbite
Canine crossbites are recorded in the Overjet assessment	

TABLE 5.--Overbite Assessment (OB)

Overbite	Open bite
score 0 Less than or equal to one third coverage fo the lower incisor	score 0 No open bite
1 Greater than one third but less than two thirds coverage of the lower incisor	1 Open bite less than or equal to 1mm
2 Greater than two thirds coverage of the lower incisor	2 Open bite 1.1 - 2 mm
3 Greater than or equal to full tooth coverage	3 Open bite 2.1 - 3 mm
	4 Open bite greater than or equal to 4 mm

TABLE 6.--Midline Assessment (MID)

score	
0	Coincident and up to one quarter lower incisor width
1	One quarter to one half lower incisor width
2	Greater than one half lower incisor width

TABLE 7.--Weightings derived from the Five Components of the PAR Index (British and U.S.A.)

Components	Weightings (British)	Weightings (U.S.A.)
1. UAS	x 1	x 1
2. RBO, LBO	x 1	x 2
3. OJ	x 6	x 5
4. OB	x 2	x 3
5. MID	x 4	x 3

The PAR Index: Conventions

A series of conventions was created to standardize the approach in assessing occlusions.

GENERAL

i) All scoring is accumulative.

ii) There is no maximum cut off level.

iii) Increased overjets, contact point displacements etc, associated with poor restorative work are not recorded.

iv) Contact point displacements between deciduous teeth and between deciduous and permanent teeth are not recorded.

v) Spaces are not recorded if the patient is to receive a prosthetic replacement.

CANINES

i) Ectopic canines which have erupted in the palate should be recorded as an anterior crossbite in the overjet section.

IMPACTIONS

i) If a tooth is unerupted due to insufficient space or is ectopic,it is recorded as impacted.

INCISORS

i) Spacing in the anterior segment resulting from extraction, agenesis, or avulsion of incisors or canines is recorded using the following protocol:

   a) if orthodontic space closure is appropriate then the space is recorded.

   b) if increasing the space is appropriate (for prosthetic replacement) then the space is only recorded if it is $\leq$ 4 mm.

ii) When recording an overjet, if the tooth falls on the line the lower score is recorded.

iii) If a lower incisor has been extracted or is missing an estimate of the lower dental midline is made.

The total sample of one hundred extraction and one hundred nonextraction cases (N = 200 cases) was scored according to the PAR criteria and weighted for malocclusion severity and treatment difficulty by using the weightings derived from the U.S.A. (Pittsburgh) validation session (DeGuzman et al., 1995). Individual scoring was done on a modified scoring sheet for both pretreatment and posttreatment study models (Appendix 2). All individuals in the sample were Caucasian. The parental occupation coding (socio-economic assessment) was determined from the patient's initial health history questionnaire and was categorized according to the "Two Factor Index of Social Position" (Hollingshead, 1957). The two factors considered in Hollingshead's analysis were:

1. The precise occupational role of the head of the household
2. The amount of formal schooling he/she had received

Since only the occupation of the parent responsible for the child's orthodontic care in our study was known, this was the only portion of the social position index that was coded.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social

Sciences (SPSS) for Windows® software (SPSS, Inc.,Chicago, IL). Mean and standard deviation for the patient's age at the start of treatment, the total active treatment duration, the experience of the operator, the pretreatment and posttreatment PAR scores, and the individual PAR components were obtained. Operator experience was calculated by counting the days from July 1, 1981 (i.e. the number of days the provider (MGH) had been practicing orthodontics) until the patient's age at the start of treatment. The parental occupation coding was divided into nine general groups. Mean, standard deviation, and frequencies were calculated for this socioeconomic assessment. Frequencies for the extraction group, the nonextraction group, and the total sample were then calculated for gender and angle's classification.

As stated previously, there are two ways of assessing outcome by the PAR Index: the numerical reduction in the weighted PAR score and the percentage reduction in the weighted PAR score. Since the American weighting system was used in this study, the only appropriate outcomes assessment measure for the PAR Index was the percentage reduction in weighted PAR score for both the extraction and the nonextraction groups. This is determined by the formula:

$$\frac{X1 - X2}{X1} \times 100\%, \text{ where } X1 = \text{Pretreatment PAR score and } X2 = \text{Posttreatment PAR score}$$

The percentage reduction (%RED) of each PAR component was also computed using this same formula. Finally, a calculation was done for the

percentage that each individual PAR component contributed to the total malocclusion (% MAL). This was determined by multiplying the pretreatment PAR score of each component by its specified weighting, then dividing this by the total pretreatment PAR score for each treatment group. Next, a linear regression model was formulated to determine the effect various independent variables had on the dependent variable. The difference in pretreatment and posttreatment PAR scores was considered the dependent variable and the following independent variables were entered into the multiple regression model:

1. Group (extraction or nonextraction)
2. Angle's classification
3. Gender
4. Patient age (years/months)
5. Total active treatment duration (months)
6. Operator experience (days)
7. Estimate of socioeconomic status

A step-wise model was calculated to determine which individual factors contributed significantly to the outcome variable. A second linear regression model was formulated to determine which factors were significant in causing a percentage reduction in PAR score. The independent variable, pretreatment PAR score, was added along with the other independent variables to the equation. Another step-wise model was run to determine

which independent variables were significant.

T-tests were run on all the independent variables to test the statistical significance of these factors to the extraction and nonextraction groups. Alpha values were set at $p \leq 0.05$.

Intraexaminer Reliability

During the initial data collection (T_a), all pretreatment and posttreatment study models of both the extraction and the nonextraction groups were scored according to the PAR Index criteria. Approximately four weeks later, thirty-three cases were randomly selected from the entire sample and the PAR score was determined a second time (T_b). In order to test for bias in the scoring of the pretreatment and posttreatment models, a test of reliability was calculated using an intraexaminer correlation coefficient of reliability (Fleiss et al., 1979). Comparisons were made between pretreatment T_a versus pretreatment T_b, posttreatment T_a versus posttreatment T_b, and pretreatment T_a - posttreatment T_a versus pretreatment T_b - posttreatment T_b.

RESULTS

Extraction Group

For the extraction group (N = 100), thirty-nine subjects were male and sixty-one were female. All were Caucasian. The average age of the group was 13.5 ± 1.4 years. The average treatment time was 29.7 ± 6.1 months. Classified according to Angle's classification criteria, the extraction group included the following:

Class I	40
Class II Division 1	35
Class II Division 2	4
Class II Subdivision Right or Left	14
Class III	7

Mean and standard deviation (sd) for the pretreatment and posttreatment PAR scores, as well as %RED and %MAL for each component are given in TABLE 8.

TABLE 8.--EXTRACTION group - Mean and standard deviation (sd) for PAR SCORE and PAR components; %RED and %MAL

	PRETREATMENT		POSTTREATMENT		%RED	%MAL
	Mean	sd	Mean	sd		
PAR SCORE	30.01	8.20	6.18	3.04	79.41	
UAS	6.05	3.85	0.09	0.32	98.51	20.16
RBO	2.01	1.18	0.82	0.41	59.20	13.40
LBO	2.12	1.22	1.11	0.49	47.64	14.13
OJ	1.82	1.01	0.14	0.38	92.31	30.32
OB	1.32	0.91	0.40	0.53	69.70	13.20
MID	0.88	0.81	0.11	0.31	87.50	8.80

Nonextraction Group

For the nonextraction group (N = 100), fifty patients were male and fifty patients were female. All were Caucasian. The average age of the group was 13.5 ± 1.2 years. The average active treatment duration was 26.0 ± 7.2 months. Classified according to Angle's classification criteria, the nonextraction group included the following:

Class I	54
Class II Division 1	29
Class II Division 2	3
Class II Subdivion Right or Left	11
Class III	3

Mean and standard deviation (sd) for the pretreatment and posttreatment PAR scores, as well as %RED and %MAL are given in TABLE 9.

TABLE 9.--NONEXTRACTION group - Mean and standard deviation (sd) for PAR SCORE and PAR components; %RED and %MAL

	PRETREATMENT		POSTTREATMENT		%RED	%MAL
	Mean	sd	Mean	sd		
PAR SCORE	25.21	8.55	5.64	3.08	77.63	
UAS	4.21	2.90	0.15	0.48	96.44	16.70
RBO	1.83	1.16	0.72	0.59	60.66	14.52
LBO	2.02	1.30	0.94	0.57	53.47	16.03
OJ	1.28	1.04	0.11	0.31	91.41	25.39
OB	1.58	0.88	0.42	0.52	73.42	18.80
MID	0.72	0.79	0.12	0.33	83.33	8.57

Total Sample

For the total sample (N = 200), eighty-nine subjects were male (44.5%) and 111 (55.5%) were female. All subjects were Caucasian. The average age of the sample was 13.5 $\pm$ 1.3 years. The average treatment time was 27.9 $\pm$ 6.9 months. Classified according to Angle's classification criterial, the sample included the following:

Class I	94	(47%)
Class II Division 1	64	(32%)
Class II Division 2	7	(3.5%)
Class II Subdivsion Right or Left	25	(12.5%)
Class III	10	(5%)

Mean and standard deviation (sd) for pretreatment and posttreatment PAR scores, as well as %RED and %MAL are given below in TABLE 10.

TABLE 10.--TOTAL SAMPLE - Mean and standard deviation (sd) for PAR SCORE and PAR components; %RED and %MAL

	PRETREATMENT		POSTTREATMENT		%RED	%MAL
	Mean	sd	Mean	sd		
PAR SCORE	27.61	8.70	5.91	3.06	78.59	
UAS	5.13	3.52	0.12	0.41	97.66	18.58
RBO	1.92	1.17	0.77	0.51	59.90	13.91
LBO	2.07	1.26	1.03	0.53	50.24	14.99
OJ	1.55	1.01	0.13	0.35	91.61	28.07
OB	1.45	0.90	0.41	0.52	71.72	15.76
MID	0.80	0.80	0.12	0.32	85.00	8.69

The mean, standard deviation, and frequencies for the occupation of the parent responsible for the orthodontic care were also calculated. The parental occupations were divided into nine general catergories. The results for the total sample included the following (N = 200):

1.	Major professionals	29
2.	Lesser professionals	35
3.	Small business owners and managers	40
4.	Clerical and sales workers	29
5.	Skilled manual workers	32
6.	Semi-skilled maual workers	18
7.	Unskilled workers	3
8.	Self-employed	9
9.	No occupation given / unemployed / retired	5

The average occupation coding for the total sample was 3.71 ± 2.03. These results provided little useful data in regard to the extraction or nonextraction decision. From the patient's health history questionnaire, only one factor, parental occupation, could be determined. If both factors of the "Two Factor Analysis" were known, perhaps a more accurate assessment could be made of the present data.

The experience of the operator was also calculated for both extraction and nonextraction groups. Mean scores determined for the extraction group were 2029.20 ± 1060.31 days. For the nonextraction group, operator experience was 2323.20 ± 1027.21 days. These results should be viewed

cautiously since it was necessary to initially screen a significantly greater number of extraction cases than nonextraction cases in order to obtain the study sample of one hundred cases.

Linear Regression

The first linear regression model run had the dependent variable entered as the difference between the pretreatment PAR score and the posttreatment PAR score (N = 200). R Square = 0.14569 or approximately 15% with a significance F = 0.0001. Step-wise regression revealed the only factors relevant to the difference in PAR scores was the Group (Extraction or Nonextraction) to which the patient belonged and the beginning Angle's classification to which the patient was categorized. The Group contributed an R Square = 0.06580 or approximately 7% to the difference in PAR score. The Angle's classification contributed R = 0.10991 or approximately 4% toward the difference in PAR score.

The second linear regression model was formulated and the dependent variable was based on the percentage reduction in pretreatment and posttreatment PAR score. The results showed R Square = 0.20899 with a significance F = 0.0000. Step-wise regression was used to reveal two significant factors:

1. Pretreatment PAR score (R Square = 0.11579 or approximately 12%)
2. The experience of the operator (R Square = 0.19104 or approximately 7%).

The results of the 2-Tail t-tests showed four independent variables had statistical significance for the dependent variable GROUP (Extraction or Nonextraction):

1. Pretreatment PAR score
   Extraction- mean 30.01 ± 8.20
   Nonextraction- mean 25.21 ± 8.55
   2-tail Sig- 0.000

2. Pretreatment Upper Anterior Segment crowding (UAS)
   Extraction- mean 6.05 ± 3.85
   Nonextraction- mean 4.21 ± 2.90
   2-tail Sig- 0.000

3. Pretreatment Overjet (OJ)
   Extraction- mean 1.82 ± 1.01
   Nonextraction- mean 1.28 ± 1.04
   2-tail Sig- 0.000

4. Treatment Duration
   Extraction- mean 29.7 ± 6.1
   Nonextraction- mean 26.0 ± 7.2
   2-tail Sig- 0.000

Reliability

Intraexaminer correlation coefficient results revealed very little evidence of bias. Pretreatment T_a versus pretreatment T_b was $r = 0.96$. Posttreatment T_a versus posttreatment T_b was $r = 0.90$. Pretreatment T_a - posttreatment T_a versus pretreatment T_b - posttreatment T_b was calculated at $r = 0.94$. The results indicated excellent reliability for the investigator, because the closer the intraexaminer coefficient (r) is to one, the more the results can be relied upon with confidence.

DISCUSSION

Since the inception of orthodontics as a dental specialty almost a hundred years ago, the extraction of teeth for orthodontic reasons has been one of the most controversial issues in the profession. Various opinions on this dilemma have been held by orthodontists in research, as well as, orthodontists in clinical practice. Most of these opinions have evolved from clinical experience and judgement, rather than research and data. Instead of evaluating the decision to extract or not to extract, the purpose of this study was to objectively and statistically assess the outcome of extraction and nonextraction orthodontic treatment using the PAR Index.

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 the 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 (DeGuzman et al., 1995). Therefore, the only way to effectively assess improvement for this study is by the percentage reduction in weighted PAR score. As determined by DeGuzman et al., (in press), a

percentage change in PAR score of 65% after orthodontic treatment reflects a great improvement in occlusal factors. As scored by the PAR Index criteria, for the extraction group the average pretreatment PAR score was 30.01, and the posttreatment PAR score averaged 6.18 (TABLE 8). The percentage reduction in the extraction group was 79.41%. For the extraction group, eighty-nine patients (89%) had percentage changes of at least 65%. This indicates a great improvement in dento-occlusal relationships and treatment to a very high standard. For the nonextraction group, the average pretreatment PAR score was 25.21, and the posttreatment PAR score averaged 5.64. The percentage reduction for the nonextraction group was 77.63% (TABLE 9). The nonextraction group had eighty-five patients (85%) with percentage changes of at least 65%. This again reflects an excellent standard of treatment.

As discussed previously, the PAR Index is composed of five weighted components: Upper anterior segment alignment (UAS); Right and Left buccal occlusion (RBO, LBO); Overjet (OJ); Overbite (OB); and Midline deviation (MID). When the pretreatment means of these components for the extraction and nonextraction groups are compared, a distinct pattern emerges. In every scored component except OB, the mean PAR score of the extraction group displays a larger number, indicating a more severe malocclusion. In other words, extraction of teeth was associated with more crowding, a more severe buccal segment occlusion, a greater overjet, and a larger midline deviation.

It could be suggested that there is susceptibility bias associated with this study due to the significant interaction between the initial severity of the malocclusion and the extraction decision. Perhaps this particular practitioner favors extractions to reduce crowding and overjet rather than other nonextraction regimens. The U.S.A. validation study (DeGuzman et al., 1995) revealed that a pretreatment PAR score of greater than forty represented a severe malocclusion. For the extraction group, ten cases (10%) had an initial PAR score greater than forty. On the contrary, the nonextraction group had only four cases (4%) greater than forty. Also, when variables were entered into linear regression models in assessing the outcome of treatment by the PAR Index, the pretreatment score (i.e. the severity of the initial dental malocclusion) had a significant effect. We can therefore conclude that the more severe the initial malocclusion, the greater the chance for the extraction decision.

By comparing the extraction to the nonextraction group for the initial Angle's classification, in the extraction group, 40% were Class I, 53% were Class II (Division 1, Division 2, or Subdivision), and 7% were Class III. Comparatively, in the nonextraction group, 54% were Class I, 43% were Class II, and 3% were Class III. For the total sample, 47% were Class I, 48% were Class II, and 5% were Class III. These percentages compared closely with totals obtained from a study of five orthodontic practices in Michigan (Vig et al., 1990). They found for their total sample of 438 patients, 43.7% were Class I, 50.8% were Class II, and 5% were Class III. By examining the

present data, the more severe malocclusions were associated with the extraction group. This is manifested by the reduced percentage of Class I malocclusions and by the increased percentage of Class II and Class III malocclusions.

Why is overbite the only component that is greater in the nonextraction group? Overbite (OB) is really a vertical dimension measurement. Because the extraction group has a smaller averaged OB component PAR score than the nonextraction group (1.32 ; 1.58), this implies that more high angle or open-bite patients were in the extraction sample. On the other hand, low angle, deep-bite patients were probably more common in the nonextraction sample. In some cases extractions are necessary to close open-bites, whereas many deep-bite cases are completed without extracting teeth. Therefore, the scores for the different components of the PAR Index confirm statistically what is "felt" clinically.

Several interesting findings relate to the percentage reduction calculated for each individual component (% RED). For example, in both the extraction and the nonextraction groups, scores for UAS, OJ, and MID were reduced by percentage reductions of greater than 85% (TABLE 10). In contrast, OB was reduced less than 75%, and RBO and LBO were reduced only an average of around 55%. This clinician found it much more difficult to effect a change in molar relationship and overbite than to correct anterior crowding or overjet. Interestingly, these factors did not seem to be related to whether or not teeth were extracted in the process.

When comparing RBO and LBO in both groups, RBO averaged approximately a 60% reduction, while LBO only averaged around a 50% reduction. This implies the provider had a statistically greater buccal segment correction on the right side. Knowing the provider (MGH) is right-handed and works from the right side of the patient, this conclusion would seem logical. However, the total sample of two hundred cases was initially categorized according to Angle's classification, and Class II, Subdivision malocclusions were recorded. From the total sample, nine were Class II Subdivision Right, and sixteen were Class II Subdivision Left; almost twice as many. This finding seems to account for the difference in reducing RBO and LBO.

Finally, the percentage of the malocclusion (% MAL) was determined for each PAR component. In this manner the total malocclusion can be divided into percentages. For the extraction group, UAS and OJ account for 50.48% of the malocclusion (TABLE 8). In the nonextraction group, UAS and OJ only account for 42.09% (TABLE 9). This demonstrates the extraction group was associated with significantly more crowding and a significantly larger overjet.

Another significant finding in the extraction and nonextraction groups were the different percentages of males and females treated in these groups. In the extraction group, the percentage of males was 39%, and the percentage of females was 61%. However, for the nonextraction group, the percentage of males was 50%, and females also made up 50% of this

group. When averaging for the total sample, 44.5% were male, and 55.5% were female. In this sample more girls than boys received orthodontic care. In two British surveys (Banks et al., 1988 and O'Brien and Corkill, 1989), 57% of the orthodontic patients were female. While these extraction and nonextraction percentages may not seem unusually different, in all three studies, females received orthodontic care to a greater extent despite the fact that the prevalence of malocclusions is the same for both sexes. Shaw et al., (1991) describe this phenomena as sex-role stereotyping "wherein society places greater emphasis on the possession of high physical attractiveness in the female." Whether this is true or not, the extraction group still had a significantly greater percentage of females than males. For both groups, the average treatment age was 13.5 years. Sexual dimorphism relating to growth spurts seem to play a role here. According to Broadbent et al., (1975),

> "the termination of active growth takes place in a plateauing of size change in the females at age 14 years; whereas the males, in contrast, are observed to continue actively in growth increments to the eighteenth and nineteent years."

With little growth remaining and little chance of affecting change through growth modification, the extraction decision for females may have been more of a factor in this particular study sample.

Most orthodontists and their patients are concerned with the length of active orthodontic treatment. By having estimates of treatment duration, clinicians can make more accurate and informed consultations to potential

patients. In this study, treatment duration was measured from the time the appliances were first placed on the teeth (band/bond date) until the day the appliances were removed (deband date). For the extraction group, the average active treatment time was 29.7 months. On the contrary, the nonextraction group had an average treatment time of 26.0 months; a difference of 3.7 months. This finding has been confirmed in other studies. Fink and Smith (1992) conducted a study of orthodontic treatment duration from private orthodontic practices. From six offices located in different areas of the country, 118 patients were evaluated. Step-wise regression analyses were used to identify the variables which had the greatest effect on treatment duration. The extraction of teeth proved to be a significant variable. For the six offices selected, the extraction cases averaged 26.2 months, while nonextraction cases averaged 22.0 months. Regression coefficients indicated that extracting a premolar added 0.9 months to the total treatment time. Therefore, 3.6 months would be added to a case with the extraction of four bicuspids. This is almost identical to the 3.7 months greater treatment duration for the extraction group in the present study.

Alger (1988) found extraction cases averaged 4.6 months longer than nonextraction cases. O'Brien et al., (1995) studied treatment outcome as it related to treatment duration in 250 Class II, Division 1 malocclusions. The authors determined that the extraction cases averaged 30.6 months to complete treatment. On the other hand, the total treatment time for the nonextraction cases was 24.8 months.

From these four studies, there is an obvious range of treatment duration from 22.0-30.6 months in both extraction and nonextraction groups. Many factors besides the extraction or nonextraction variable need to be considered when evaluating treatment duration. Poor patient compliance (i.e. missed appointments, broken appliances) also increases treatment time. Another variable that should be considered is the time spent in detailed "finishing" of the case. Correcting large occlusal problems occurs more rapidly in treatment than the more tedious tasks in finishing procedures such as root paralleling and root torquing. There are clearly differences in the emphasis different clinicians place on the importance of the finishing details of a case. Because of this, differences in treatment duration will naturally occur among providers. Although this study did not address these issues, these factors should be randomly distributed between the extraction and nonextraction groups and would have equal significance for either group. However, it is safe to conclude from this study that the extraction of teeth increased treatment duration significantly.

After collecting the PAR data from the pretreatment and posttreatment study models and the descriptive data for the patient treatment records, it was necessary to determine which factors were important in assessing the outcome of orthodontic treatment. Since there are two methods of assessing outcome by the PAR Index, linear regression models were formulated to determine what effect the various independent variables had on the two dependent variables:

1. The difference in pretreatment and posttreatment PAR score

2. The percentage reduction in PAR score

The first linear regression model showed only 15% of the variability could be explained by the final model. Step-wise regression revealed the only significant factors relative to the difference in PAR score were the initial group the patient belonged (extraction or nonextraction) and the initial Angle's classification the case was categorized. This suggests for a greater difference between pretreatment and posttreatment PAR score, it is necessary to have a more severe initial malocclusion. This finding has been confirmed in two previous studies by O'Brien et al., (1995) and Berg and Fredlund (1981).

The second linear regression model determined that only 21% of the variance could be explained by the regression model. This implies almost 80% of the variability in percentage PAR reduction was influenced by other factors not included in the regression model. Since the study sample was confined to growing patients (below the age of sixteen), a likely source of this variability is growth. Also, the various treatment mechanics, appliances, etc., of the operator would account for much of this variability. It is important to note that the majority of the outcome of orthodontic treatment which is assessed by the percentage reduction in PAR score is still in the hands of the clinician, rather than in inherent factors in which the clinician has no direct control.

Step-wise regression showed that the percentage reduction in PAR score was related to the experience of the operator and also, to the initial pretreatment PAR score. There was a direct correlation between the experience of the operator (MGH) and the percentage reduction in PAR score. The results here should be viewed with caution due to the selection process of the cases. As stated in the Methods and Materials, the cases selected began at case number one. In order to obtain one hundred extraction cases that met the defined criteria, it was necessary to review many more study models and treatment records than the nonextraction group. This meant that the cases selected after the provider had been in practice for five years would naturally have more experience attributed to the provider than those cases chosen after only two years. In this way, the extraction group related to the experience of the operator in a dependent fashion. However, in a study of hospital based orthodontic clinics in England and Wales, O'Brien et al., (1993) confirmed that operator experience did relate to percentage reduction in PAR score. They found that senior operators improved cases 70.8%, while junior operators improved cases only 63.8%.

The second factor significant to the percentage reduction in PAR score was the initial pretreatment PAR score. As discussed earlier, for the extraction group, the percentage reduction in weighted PAR score was 79.41%, while the percentage reduction for the nonextraction group was 77.63%. How can the percentage reduction in weighted PAR score be

greater in the extraction group when the initial malocclusions were more severe? An earlier example stated that reducing a weighted, pretreatment PAR score from 50 to a weighted posttreatment PAR score of 10 resulted in a percentage reduction of 80%. If the pretreatment score had been higher than 50, for example 52, and still reduced to the same posttreatment score of 10, then the percentage reduction would now be 80.8%. From the results obtained in the study, the pretreatment PAR scores for the extraction group were significantly higher than the nonextraction group, whereas the posttreatment scores for both groups were remarkably similar. This would account for a higher percentage reduction in PAR score for the extraction group. This pattern of differences in PAR scores between the extraction group and the nonextraction group at the beginning of treatment and marked similarities in all components of PAR scores at the end of treatment represents the essential findings of this study.

To test which independent factors were significant between the extraction and the nonextraction groups, 2-Tail t-tests were run. The results showed the only significant variables were pretreatment UAS, pretreatment OJ, pretreatment PAR score, and treatment duration. Hence, the extraction group is associated with increased maxillary anterior crowding and increased overjet. This leads to a higher pretreatment PAR score which yields a longer treatment duration. As assessed by the PAR Index, the differences between the extraction group and the nonextraction group are present at the beginning of treatment; not at the end. In all components of

the PAR Index in both groups, the posttreatment results are statistically identical. Therefore, the answer to the basic research question, "Is there a difference between the outcome of orthodontic treatment between extraction and nonextraction treatment as assessed by the PAR Index?" is "No"; the outcome of both treatment modalities is incredibly similar.

Limitations of the PAR Index

While there are many benefits in the use of the PAR Index, numerous limitations must also be understood. The PAR Index only measures dento-occlusal change: therefore, it does not take into account changes in soft tissue as a result of orthodontic treatment. It does not measure orthodontic treatment need; it only measures the change in the malocclusion from the beginning to the end of orthodontic treatment. Hence, the PAR Index should not be used for screening potential orthodontic patients for allocating third-party payment plans.

Because the index only measures study models, there is no account for decalcification, gingival recession, root resorption, or TMJ considerations that may result from orthodontic treatment. Also, by only measuring dental casts, other diagnostic aids such as cephalograms and patient photographs are not used in the assessment. The PAR Index is not sensitive to the highly specific and fine details of an ideally finished case. The PAR Index has been questioned by several authors in the scoring of mixed dentition cases. It is also not advised for grading limited treatment cases, since only limited goals would be sought by treatment.

SUMMARY AND CONCLUSIONS

The decision to extract teeth for orthodontic treatment purposes has been the most debated issue in the specialty for almost a hundred years. However, little data exists on the dento-occlusal relationships of the teeth following extraction or nonextraction orthodontic treatment. Because an orthodontist specializes in correcting malocclusions by carefully aligning teeth into proper functional positions, the most obvious way to assess treatment outcome is simply to grade the orthodontic movement of teeth.

The Peer Assessment Rating (PAR) Index was used to assess the outcome of orthodontic therapy between cases treated with the extraction of four bicuspids and cases treated without the extraction of permanent teeth. From a population of 1,198 consecutively completed orthodontic cases, a study sample of two hundred was selected; one hundred extraction cases and one hundred nonextraction cases. All patients selected for inclusion in the two study groups were Caucasian, had no deciduous teeth present at the start of treatment, and were under the age of sixteen at the start of treatment. The extraction group was composed of cases treated with the extraction of only four bicuspids and the nonextraction group was treated without the extraction of any permanent teeth.

Pretreatment and posttreatment study models were scored using the

PAR Index criteria. Descriptive data was abstracted from patient treatment records to provide additional variables in comparing the extraction and nonextraction groups. Linear regression models and t-tests were used to determine if statistical significance existed between the two treatment groups. The results of this study showed:

1. On average, extraction orthodontic treatment takes 3.7 months longer to complete than nonextraction therapy.

2. As assessed by the PAR Index, the extraction group was associated with a significantly higher pretreatment:

    a. PAR score

    b. Upper anterior segment crowding (UAS)

    c. Overjet (OJ)

3. The percentage reduction in weighted PAR score for the extraction group was 79.41% and 77.63% for the nonextraction group. This indicates an excellent improvement in dento-occlusal relationships and orthodontic treatment at a very high standard in both treatment groups.

4. In all five components of the PAR Index, the extraction and the nonextraction groups were indistinguishable at the end of orthodontic treatment.

The results of this project show that although marked differences in these two groups exist prior to initiating orthodontic treatment, they are statistically identical at the end of treatment. This suggests that whether or not teeth are extracted in orthodontic cases, the clinician is able to complete the cases with equal results. However, due to loss of dental units and an extended treatment time, the benefits of extraction treatment should far

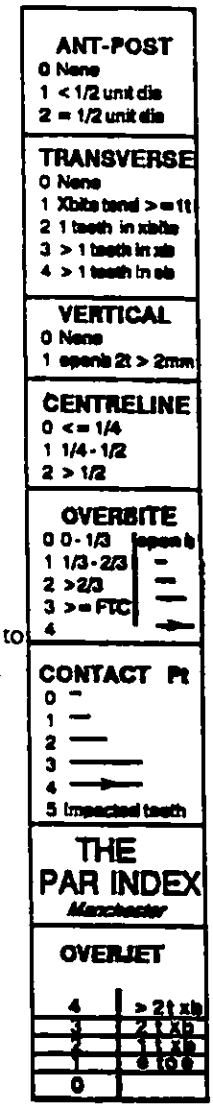
outweigh the risks before initiating this course of treatment. The ultimate outcome of orthodontic treatment in either extraction or nonextraction treatment should produce the best esthetic result within the bounds of function and stability.

Clinical Significance

Uses of the PAR Index

With the increased interest in outcomes assessment in orthodontics a method for measuring is needed. Since the specialty is not in agreement concerning this matter, the only way to objectively quantify outcomes presently is by the use of occlusal indices. The PAR Index was developed specifically to assess the outcome of orthodontic treatment. It has been proven to be valid and reliable in this assessment. It reduces subjectivity by the index's defined criteria. The PAR Index is a rapid and accurate method of measuring dento-occlusal changes from study models. The index is easy to learn and can be taught to non-dental personnel. It ensures uniform interpretation of results and is sensitive enough to be used for research and epidemiological data collection. It has been recommended to be used for personal audit for quality assurance and for comparisons between various systems of patient care delivery.

APPENDIX 1. The PAR ruler



The first 3 sections provide a short hand summary of the buccal occlusion. Antero-posterior. transverse and vertical scores are summed for each buccal segment.

This section summarises centreline ratings. Centreline is recorded in relation to lower incisor width.

The overbite section allows recording of overlap in relation to the coverage of the lower incisors. Openbite is recorded by reference to the length of the lines on the right.

Contact point displacement. The length of the line is matched to the contact point displacements. If the distance between the contact points is greater than the line. the higher rating applies. Contact point displacements are summed for each anterior segment.

ABBREVIATIONS

xbite, xb	-	crossbite.
sb	-	scissors bite
open b	-	open bite.
FTC	-	full tooth coverage
t	-	tooth/teeth.
e to e	-	edge to edge.
tend	-	tendency
1/2 unit dis	-	half unit discrepancy (cusp to cusp)

This section summarises overjet and anterior crossbite ratings. These ratings are summed if both are present.

APPENDIX 2. The PAR scoring sheet

Patient_____ Rater_____ Date_____

PAR INDEX COMPONENT	SUB-COMPONENTS	RAW PAR SCORE	WEIGHTING PITTSBURGH (MANCHESTER)	WEIGHTED PAR SCORE
Maxillary Anterior Alignment	Displacement			
	Impaction			
	Total		1 (1)	
Right Buccal Occlusion	Antero-posterior			
	Vertical			
	Transverse			
	Total		2 (1)	
Left Buccal Occlusion	Antero-posterior			
	Vertical			
	Transverse			
	Total		2 (1)	
Overjet	Overjet			
	Anterior Crossbites			
	Total		5 (6)	
Overbite	Overbite			
	Openbite			
	Total		3 (2)	
Centerline	Total		3 (4)	
TOTAL SCORE				

LITERATURE CITED

Afsharpanah, A, S Nelson, R Feghali and MG Hans. 1995. Assessment of an orthodontically untreated sample using the P.A.R. Index. J Dent Res (IADR Abstract 1019) 74:139.

Alger, DW. 1988. Appointment frequency versus treatment time. Am J Othod Dentofac Orthop 94:436-439.

Angle, EH. 1899. Classification of malocclusion. Dent Cosmos 41:248-264.

Banks, PA, CM Corkill, DE Bowden, PH Morse and WC Shaw. 1988. The consultant orthodontic service; 1985 survey. Br Dent J 165:425-429.

Beattie, JR , DE Paquette and LE Johnston. 1994. The functional impact of extraction and nonextraction treatments: A long-term comparison in patients with "borderline," equally susceptible Class II malocclusions. Am J Orthod Dentofac Orthop 105:444-449.

Berg, R and A Fredlund. 1981. Evaluation of orthodontic treatment results. Eur J Orthod 1:55-68.

Bishara, SE, JM Chadha and RB Potter. 1973. Stability of the intercanine width, overbite, and overjet correction. AmJ Orthod Dentofac Orthop 63:588-595.

Bishara, SE, DM Cummins, JR Jackobsen and JR Zaher. 1995. Dentofacial and soft tissue changes in Class II, Division 1 cases treated with and without extractions. AmJ Orthod Dentofac Orthop 107:28-37.

Bishara, SE, AR Zaher, DM Cummins and JR Jakobsen. 1994. Effects of orthodontic treatment on the growth of individuals with Class II division 1 malocclusion. Angle Orthod 64(3):221-230.

Bowbeer, GR. 1987. The sixth key to facial beauty and TMJ health. Funct Orthod 4:4-22.

Broadbent, BH, BH Broadbent Jr and WH Golden. 1975. Bolton Standards of Dentofacial Developmental Growth. St. Louis. The C.V. Mosby Company. 13-14.

Buchanan, IB, WC Shaw, S Richmond, KD O'Brien and M Andrews. 1993. A comparison between the PAR and the Summer's occlusal indices. Eur J Orthod 15:27-37.

Case, CS. 1911. The question of extraction in orthodontia. Trans NDA (reprinted Am J Orthod Dentofac Orthop 1964; 50:660-691).

Chua, AL, JY Lim and EC Lublt. 1993. The effects of extraction versus nonextraction orthodontic treatment on the growth of the lower anterior face height. Am J Orthod Dentofac Orthop 104:361-368.

DeGuzman,L , D Bahireai, KD O'Brien, RJ Weyant , K Dryland-Vig and PS Vig. (in press). The validation of a Brithish Occlusal Index. Am J Orthod Dentofac Orthop.

DeGuzman, L, K Bahiraei, KW Vig, PS Vig, RJ Weyant and KD O'Brien. 1995. The validation of the Peer Assessment Rating Index for malocclusion severity and treatment difficulty. Am J Orthod Dentofac Orthop 107:172-176.

Draker, HL. 1960. Handicapping labio-lingual deviations: a proposed index for public health purposes. Am J Orthod Dentofac Orthop 46:295-305.

Drobocky, OB and RJ Smith. 1989. Changes in facial profile during orthodontic treatment with extraction of four first premolars. Am J Orthod Dentofac Orthop 95:220-230.

Farrar, WB and WL McCarty. 1983. A Clinical Outline of Temporomandibular Joint Diagnosis and Treatment. Montgomery, Alabama. Walker. 84-85.

Feghali, R, S Nelson, A Afsharpanah and MG Hans. 1995. Assessment Of An Orthodontic Clinic Using The P.A.R. Index. J Dent Res (Abstract 1021) 74:139.

Feinstein, AR. 1985. Cinical Epidemiology: The Architecture of Clinical Research. Philadelphia. W.B. Saunders. 265-266.

Fink, DF and RJ Smith. 1992. The duration of orthodontic treatment. Am J Orthod Dentofac Orthop 102:45-51.

Fleiss, JL, MJ Slakter, SL Fischman, MH Park and NW Chilton. 1979. Inter-examiner reliability in caries trials. J Dent Res 58(2):604-609.

Fox, NA. 1993. The first 100 cases: A personal audit of orthodontic treatment assessed by the PAR (peer assessment rating) index. Br Dent J 174:290-297.

Fricton, JR and EL Schiffman. 1986. Reliability of a craniomandibular index. J Prosthet Dent 65:1359-1364.

Gottlieb, EL, AH Nelson and DS Vogels. 1986. JCO study of orthodontic diagnosis and treatment procedures. Part 1. Overall results. J Clin Orthod 20: 612-625.

Gianelly, AA, CK Anderson and J Boffa. 1991. Longitudinal evaluation of condylar position in extraction and nonextraction treatment. Am J Orthod Dentofac Orthop 100:416-420.

Glenn, G, PM Sinclair and RG Alexander. 1987. Nonextraction orthodontic therapy: Posttreatment dental and skeletal stability. AmJ Orthod Dentofac Orthop 92:321-328.

Grainger, RM. 1967. Othodontic treatment priority index. Washington. U.S. Government Printing Office. PHS publication no 1000, Series 2, No. 25.

Hahn, G. 1944. Extraction panel. Orthodontics: Its objectives, past and present. Am J Orthod Dentofac Orthop 20:401-404.

Hollingshead, AB. 1957. Two Factor Index of Social Position. New Haven, Connecticut. August B. Hollingshead. 2-11.

Janson, M and A. Hasund. 1981. Functional problems in orthodontic patients out of retention. Eur J Orthod 3:173-179.

Kerr, WJ and IB Buchanan. 1993. Use of the PAR Index in assessing the effectiveness of removable orthodontic appliances. Br J Orthod 20:351-357.

Little, RM. 1990. Stability and relapse of dental arch alignment. Br J Orthod 17:235-241.

Little, RM, TR Wallen and RA Riedel. 1981. Stability and relapse of mandibular anterior alignment; first premolar extraction cases treated by traditional edgewise orthodontics. Am J Orthod Dentofac Orthop 80:349-364.

Luecke, PE and LE Johnston. 1992. The effect of first premolar extraction and incisor retraction on mandibular position: Testing the central dogma of "funtional orthodontics." Am J Orthod Dentofac Orthop 101:4-12.

Luppanapornlarp, S and LE Johnston. 1993. The effects of premolar-extraction: A long-term comparison of outcomes in "clear-cut" extraction and nonextraction Class II patients. Angle Orthod 63:257-272.

O'Brien, KD. 1995. Personal communication by e-mail. January 10,1995.

O'Brien, KD and CM Corkill. 1989. The specialist orthodontic practioner. The 1989 survey. Br Dent J 168:471-475.

O'Brien, KD, R Robbins, KW Vig, PS Vig and R Weyant. 1995. The effectiveness of Class II, Division 1 treatment. Am J Orthod Dentofac Orthop 107:329-334.

O'Brien, KD, WC Shaw and CT Roberts. 1993. The use of occlusal indices in assessing the provision of orthodontic treatment by the hospital orthodontic service of England and Wales. Br J Orthod 20:25-35.

O'Brien, KD and RJ Weyant. 1993. Process analysis of treatment provided by the hospital orthodontic service. Br J Orthod 20:131-134.

O'Connor, BM. 1993. Contemporary trends in orthodontic practice: A national survey. Am J Orthod Dentofac Orthop 103:163-170.

Paquette, DE, JR Beattie and LE Johnston. 1992. A long-term comparison of nonextraction and premolar extraction edgewise therapy in "borderline" Class II patients. Am J Orthod Dentofac Orthop 102:1-14.

Parker, CD, RS Nanda and GF Currier. 1995. Skeletal and dental changes associated with the treatment of deep bite malocclusion. Am J Orthod Dentofac Orthop 107:382-393.

Peck, S and H Peck. 1979. Frequency of tooth extraction in orthodontic treatment. Am J Orthod Dentofac Orthop 76:491-496.

Proffit, WR. 1994. Forty-year review of extraction frequencies at a university orthodontic clinic. Angle Orthod 64(6):407-414.

Reynders, RM. 1990. Orthodontics and temporomandibular disorders: a review of the literature. Am J Orthod Dentofac Orthop 97:463-471.

Richmond, S. 1990. A critical evaluation of orthodontic treatment standards in the general dental service in England and Wales. PhD Thesis, University of Manchester.

Richmond, S. 1993. Personal audit in orthodontics. Br J Orthod 20:135-144.

Richmond, S and M Andrews. 1993. Orthodontic treatment standards in Norway. Eur J Orthod 15:7-15.

Richmond, S, KD O'Brien, IB Buchanan and D Burden. 1994. An Introduction to Occlusal Indices. Manchester. Mandent Press. 16-21.

Richmond, S, WC Shaw, KD O'Brien, IB Buchanan, R Jones, CD Stephens, CT Roberts and M Andrews. 1992a. The development of the PAR Index (Peer Assessment Rating): reliability and validity. Eur J Orthod 14:125-139.

Richmond, S, WC Shaw, CT Roberts and M Andrews. 1992b. The PAR Index (Peer Assessment Rating): Methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 14:180-197.

Richmond, S, WC Shaw, CD Stephens, WG Webb, CT Roberts and M Andrews. 1993. Orthodontics in the general dental service of England and Wales: A critical assessment of standards. Br Dent J 174:315-329.

Riedel, RA. 1960. A review of the retention problem. Angle Orthod 30:179-184.

Rossouw, PE, CB Preston, CJ Lombard and JW Truter. 1993. A longitudinal evaluation of the anterior border of the dentition. Am J Orthod Dentofac Orthop 104:146-152.

Sadowsky, C. 1992. The risk of orthodontic treatment for producing temporomandibular mandibular disorders: A literature overview. Am J Orthod Dentofac Orthop 101:79-83.

Sadowsky, C and E BeGole. 1980. Long-term status of temporomandibular function and functional occlusion after orthodontic treatment. Am J Orthod Dentofac Orthop 78:201-212.

Sadowsky, C and AM Polson. 1984. Temporomandibular disorders and functional occlusion after orthodontic treatment: Results of two long-term studies. Am J Orthod Dentofac Orthop 86:386-390.

Salzmann, JA. 1968. Handicapping malocclusion assessment to establish treatment priority. Am J Orthod Dentofac Orthop 54:749-765.

Shaw, WC, S Richmond, KD O'Brien and S Richmond. 1991. Quality control in orthodontics: Factors influencing the receipt of orthodontic treatments. Br Dent J 99:66-68.

Shields, TE, RM Little and MK Chapko. 1985. Stability and relapse of mandibular anterior alignment: A cephalometric appraisal of first-premolar-extraction cases treated by traditional edgewise orthodontics. Am J Orthod Dentofac Orthop 87:27-38.

Staggers, JA. 1994. Vertical changes following first premolar extractions. Am J Orthod Dentofac Orthop 105:19-24.

Stephens, CD, KJ Drage, S Richmond, WCShaw, CT Roberts and M Andrews. 1993. Consultant opinion on orthodontic treatment plans used by dental practitioners: a pilot study. J Dent 21:355-359.

Summers, CJ. 1971. A system for identifying and scoring occlusal disorders. Am J Orthod Dentofac Orthop 59:552-557.

Tweed, CH. 1966. Clinical Orthodontics. St. Louis. The C. V. Mosby Company. 42.

Tweed, CH. 1944. Indications for the extraction of teeth in orthodontic procedure. Am J Othod Dentofac Orthop 20:405-428.

Vayda, D, KD O'Brien, H Shnorhokian, KW Vig, PS Vig and R Weyant. 1994. Severity of malocclusion and reduction in PAR: Class I versus Class II. J Dent Res (IADR Abstract 1371) 73:273.

Vig, KW, KD O'Brien, H Shnorhokian, D Vayda, PS Vig, R Weyant, C Colella, J Izen and R McGrogan. 1994. Predictors for Class I and Class II treatment duration difference. J Dent Res (IADR Abstract 1372) 73:273.

Vig, PS, JA Weintraub, C Brown and CJ Kowalski. 1990. The duration of orthodontic treatment with and without extractions: A pilot study of five selected practices. Am J Orthod Dentofac Orthop 97:45-57.

Weintraub, JA, PS Vig, C Brown and CJ Kowalski. 1989. The prevalence of orthodontic extractions. Am J Orthod Dentofac Orthop 96:462-466.

Witzig, JW and TJ Spahl. 1987. The Clinical Management of Basic Maxillofacial Orthopedic Appliances. Littleton, Massachusetts. PSG Publishing. 161-216.

Wyatt, WE. 1987. Preventing adverse effects on the temporomandibular joint through orthodontic treatment. Am J Orthod Dentofac Orthop 91:493-499.

Young, TM and RJ Smith. 1993. Effects of orthodontics on the facial profile: A comparison of changes during nonextraction and four premolar extraction treatment. Am J Orthod Dentofac Orthop 103:452-458.

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