# THE AFFECTS OF OPERATOR EXPERIENCE ON ORTHODONTIC TREATMENT OUTCOME

by

CLARENCE JAMES RED, III

Submitted in partial fulfillment of the requirements

for the Degree of Master of Science in Dentistry

Thesis Advisor: Dr. Mark G. Hans

Department of Orthodontics

School of Dentistry

CASE WESTERN RESERVE UNIVERSITY

January 16, 1998

CASE WESTERN RESERVE UNIVERSITY

SCHOOL OF DENTISTRY

GRADUATE STUDIES

We hereby approve the thesis of

Clarence James Reed, III

candidate for the degree Master of Science

in Dentistry.

Signed: _____ (Chairman)

_____

Sudhir Nelson

_____

_____

Date: January 16, 1998

THE AFFECTS OF OPERATOR EXPERIENCE ON ORTHODONTIC TREATMENT OUTCOME

Abstract

by

CLARENCE JAMES RED, III

The Peer Assessment Rating (PAR) index is one measure of orthodontic treatment outcome. The present study used the PAR index to assess the affects of operator experience, defined as the number of days the operator has been practicing orthodontics when a given patient started treatment, on orthodontic treatment outcome. Three hundred subjects were selected from a group of 1314 treated by a single practitioner (MGH) between 1981 and 1997. Group T1 included the first 100 consecutively finished patients, group T2 the middle 100 consecutively finished cases and group T3 the most recent 100 finished cases. Pre-treatment and post-treatment PAR score, age at the start of treatment, treatment duration, the extraction decision, and the operator experience were recorded for all subjects. An ANOVA was used to examine differences among groups with a p-value of 0.05 used for statistical significance. The results showed no statistical significant differences among the groups for the three time periods for any of the variables studied. Pooling the three

datasets yielded the following mean values: Pre-treatment age = 12.4 $\pm$ 0.5 years; Pre-treatment PAR score = 21.8 $\pm$ 9.1; Post-treatment PAR score = 5.7 $\pm$ 3.5; Percentage reduction in PAR = 73.9%; Treatment duration = 30.2 $\pm$ 12.2 months; Extraction rate = 27%. An analysis demonstrated that the operator was equally successful in correcting tooth position at all time periods. Therefore, it was concluded that differences in orthodontic outcome based on the length of time in clinical practice could not be shown for the operator studied using the PAR Index.

ACKNOWLEDGEMENTS

To my classmates, Jamie Signorino, Hsin Hsin Wu, Martin Palomo, and Virginia Luks, and the classes of 1996 and 1998, especially Vidya Armogan and David Harmon for all the help, understanding, and friendship.

To my thesis committee, Drs. Mark Hans, Arthur Phelps, and Suchi Nelson for the guidance in this project. In addition, a special thanks to Roland Feghali for introducing and educating me on the PAR Index.

To the faculty and staff in the Department of Orthodontics at CWRU for giving me a phenomenal gift, the profession of orthodontics.

TABLE OF CONTENTS


Page

ABSTRACT ..... ii

DEDICATION ..... iv

ACKNOWLEDGEMENTS ..... v

TABLE OF CONTENTS ..... vi

LIST OF TABLES ..... vii

INTRODUCTION ..... 1

REVIEW OF THE LITERATURE ..... 4

STATEMENT OF THE HYPOTHESIS ..... 33

METHODS AND MATERIALS ..... 34

RESULTS ..... 38

DISCUSSION ..... 48

SUMMARY AND CONCLUSIONS ..... 59

APPENDICES

APPENDIX 1. The PAR ruler ..... 61

APPENDIX 2. The PAR scoring sheet ..... 62

APPENDIX 3. Data Sheet ..... 63

LITERATURE CITED ..... 68

LIST OF TABLES


| Table | | Page |
|---|---|---|
| 1. | Sample Demographics | 38 |
| 2. | Outcome Measures | 38 |
| 3. | Total Sample Angle's Classification | 39 |
| 4. | Total Sample - Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction | 39 |
| 5. | Total Sample Age Versus PAR Score and Percentage Reduction | 40 |
| 6. | Total Sample Classified by Age at Pre-treatment | 40 |
| 7. | T1 Angle's Classification | 41 |
| 8. | T1 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction | 42 |
| 9. | T2 Angle's Classification | 42 |
| 10. | T2 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction | 43 |
| 11. | T3 Angle's Classification | 43 |
| 12. | T3 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction | 44 |
| 13. | Angle's Classification Versus Treatment (Months) Total Sample (T1 + T2 + T3) | 44 |

Table

Page

14. Angle's Classification Versus PAR Score and Percentage Reduction ..... 45

15. Classification Versus PAR Score and Percentage Reduction (T1) ... 45

16. Classification Versus PAR Score and Percentage Reduction (T2) ... 46

17. Classification Versus PAR Score and Percentage Reduction (T3) ... 46

# INTRODUCTION

In recent years outcome assessment has gained popularity in the profession of orthodontics. Interest in outcomes assessment was stimulated by the Department of Health and Social Security (DHSS) of the British Health Care System. In an attempt to improve the standard of dental care in England, two occlusal indices were developed. The Index of Orthodontic Treatment Need (IOTN) was designed to measure the need for orthodontic treatment, and the Peer Assessment Rating (PAR) Index was designed to measure the quality of orthodontic treatment.

One goal of the PAR Index was to decrease the degree of subjectivity in the assessment of orthodontic treatment outcome. To be useful an index must be precise, repeatable, and quantitative. It also must be valid and reliable. The PAR Index meets these requirements. The PAR Index is a weighted measuring system that uses six occlusal variables. A PAR score is representative of the amount a case deviates from normal occlusion (Richmond et al. 1992). This index was developed in such a manner that a perfect alignment of teeth would score as a zero, and a gross malalignment of teeth would score as forty or higher.

Outcome assessment is a valuable tool which has been used to evaluate orthodontic treatment. Trends such as extraction percentage, treatment duration, PAR score, percent reduction, age, and malocclusion are all variables which have been

studied with the use of outcome assessment.

The decision to extract permanent teeth for orthodontic purposes and the resulting extraction percentage among patients has been used as another measure of orthodontic outcome. Angle believed that extraction of teeth for orthodontic purposes was intolerable. It was written,

> "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 compliment of teeth, and that each tooth shall be made to occupy its normal position - normal occlusion." (Hahn 1944)

Case disagreed with this viewpoint since it was not based on biologic principles. Case examined his patient population and noted a large number of bimaxillary protrusion cases, and wrote,

> "Will the gentleman 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)

Although both these points of view have attracted many followers, the decision to extract or not ultimately is made by the practitioner and experienced by the patient.

Treatment duration has received less attention in the literature, but is an important variable from the point of view of the patient. From the patient's perspective, it could be argued that the most favorable outcomes of orthodontic therapy would be the straightest teeth, i.e., the lowest PAR score in the shortest amount of time without removal of dental units.

Although it is generally believed that increased operator experience leads to

better results, little evidence exists to support this assumption. The purpose of this study is to gain an understanding of the affect of operator experience on three measures of orthodontic outcome; PAR score, treatment duration, and extraction percentage. In, short this is an attempt to begin to answer the question: "Do orthodontists improve with time?"

# REVIEW OF THE LITERATURE

## Outcomes Assessment

### Occlusal Indices

In recent years outcome assessment has gained popularity in the literature. Outcome assessment is a standardized method to grade orthodontic treatment. In an attempt to reduce subjectivity in the analysis of orthodontic treatment, indices have been developed to indicate the level of success of orthodontic treatment. Occlusal indices have been used for various reasons including the comparison of extraction versus non-extraction treatment, as a measure of treatment success, and as a personal audit of orthodontic treatment results.

### Development of the PAR Index

The development of occlusal indices was initiated by the British Health Care System in 1984. Specifically, the Department of Health and Social Security (DHSS) in Great Britain published a report stating that unnecessary dental treatment was being provided to patients. A board was set up to evaluate this claim, and their findings were published in the "Schanschieff Report" (Richmond 1992b). The Schanschieff Report identified several areas that needed improvement to raise the level of dental care in England. One suggestion was to develop occlusal indices that could be used by the Dental Practice Board to assess orthodontic treatment need and treatment

outcome. The Occlusal Index Committee was formed and two occlusal indices were developed, the Index of Orthodontic Treatment Need (IOTN) and the Peer Assessment Rating (PAR) Index. Presently, both of these occlusal indices are used by the British Health Care System Dental Practice Board to assess orthodontic skills (Richmond et al. 1993; Richmond 1992b; Lunn et al. 1993; Stephens et al. 1993). The PAR Index was developed as an objective assessment of orthodontic treatment outcome. The goal was to identify occlusal variables that were precise, repeatable, and quantitative (Richmond et al. 1992).

The British Orthodontic Standards Working Party was organized. Ten experienced orthodontists met in a series of six meetings to formulate the PAR Index. The group examined more than two hundred dental casts and then discussed the dental components of malocclusion. The PAR Index was developed in such a way that a score for every occlusal irregularity was included. All scoring was cumulative, with no maximum cut-off level. The PAR Index was designed in such a way that perfect alignment of teeth would result in a score of a zero. In addition, a final score of ten-or-less indicates acceptable dental alignment and occlusion (Richmond et al. 1992). A score greater than ten indicates some degree of malocclusion. Thus, PAR score represents the amount the dental casts deviate from normal occlusion. Normal occlusion is defined as "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). Richmond et al. (1994) indicated that the

difference between the initial (pre-treatment) PAR score and the final (post-treatment) PAR score is one measure of treatment outcome.

## Properties of an Occlusal Index

Many authors have attempted to measure occlusion for epidemiologic purposes. Summers (1971) developed an index of occlusion and standardized the terminology, concepts, and methodology of occlusal indices. DeGuzman et al. (1995) determined the two basic requirements of an occlusal index, the first was validity and the second that it be reliable. In addition, the index should be easy to learn and apply. The index should have sensitivity and be acceptable to the profession and the public. Index scores should be objective and amenable to statistical analysis.

## Validity

Does the index measure what it is designed to measure? In 1992, Richmond et al., described how the validity of the PAR Index was determined. They compared the PAR Index measurements against the subjective dental opinion of dentists with regard to malocclusion severity. A group of seventy-four dentists (forty-eight orthodontists and twenty-six general dentists) from Great Britain participated in the validation study. All seventy-four dentists PAR scored 160 orthodontic cases. Multiple regression was used to determine if a PAR component predicted treatment outcome. Of the fifty variables examined, eleven components were identified as having predictive value, these eleven were then weighted according to British orthodontic opinion.

A similar validation study was conducted by DeGuzman et al. (1995) at the University of Pittsburgh with a group of orthodontists from the United States. Eleven orthodontists examined two hundred dental casts with various malocclusions. All subjects were treated at the University of Pittsburgh School of Dental Medicine. The eleven orthodontists rated treatment outcome on the basis of treatment duration, the anticipated difficulty of treatment, and the degree the dental casts deviated from ideal occlusion at the beginning and end of treatment. Multiple regression and correlations were completed to determine the U.S.A. weightings for the components of the PAR Index. These weightings differed from the British weightings.

The PAR Index originally included eleven components:

1) Upper right segment
2) Upper anterior segment
3) Upper left segment
4) Lower right segment
5) Lower anterior segment
6) Lower left segment
7) Right buccal occlusion
8) Left buccal occlusion
9) Overjet
10) Overbite
11) Centerline

Richmond et al. (1992) reported that maxillary and mandibular buccal segment alignment did not predict malocclusion severity. Therefore, O'Brien (1993) suggested that these four components of PAR be discontinued, reducing the number of PAR components to seven. DeGuzman et al. (1995) reported no predictive affect of lower incisor crowding, which resulted in this measure being eliminated from the PAR Index. Presently, the PAR Index is composed of six scored components:

1) Upper anterior segment crowding (UAS)
2) Right buccal segment occlusion (RBO)
3) Left buccal segment occlusion (LBO)
4) Overjet (OJ)
5) Overbite (OB)
6) Midline deviation (centerline) (MID)

In 1993, Buchanan et al. compared the validity of Summers' Occlusal Index (OI) with the PAR Index. A sample of eighty pre-treatment and post-treatment models were used to calculate correlation coefficients. The correlation coefficient for Summers' Occlusal Index was $r = 0.94$ and for the PAR Index $r = 0.85$. A two-tailed t test found no significant differences between these two indices. The authors concluded that both the PAR Index and Summers' Occlusal Index were valid outcome measures.

## Reliability

Richmond et al. (1992) published results that indicated excellent

intarexaminer and interexaminer reliability. Thirty-eight cases were selected to be PAR scored by four calibrated examiners. Intraexaminers reliability was tested using intraclass correlation coefficients of reliability (Fleiss et al. 1979). The intraclass correlation coefficient is a useful statistic for measuring consistency because it provides a single summary index of reliability. A confidence level of $r = 0.95$ or greater is indicative of results which are reliable. In the Richmond et al. study (1992), the interexaminer reliability was $r = 0.91$ and the intraexaminer reliability was $r = 0.95$.

Buchanan et al. (1993) utilized the same sample from the study completed by Richmond et al. (1990). Thirty-eight dental casts were evaluated, intraclass correlation was computed to indicate reliability. The results indicated that the PAR score reliability was $r = 0.96$ and Summers' Occlusal Index was $r = 0.97$. The authors confirmed that the PAR Index was as reliable as Summers' Occlusal Index in assessing treatment outcome.

## Estimating Improvement Using the PAR Index

The PAR Index was developed in order to assess the amount of improvement resulting from treatment. Two methods are used to assess the amount of improvement in the PAR Index, numerical reduction in the weighted PAR score and percentage reduction. However, because the initial pre-treatment PAR score influences the amount of improvement possible at post-treatment, numeric reduction in PAR score is only a good indicator of improvement in treatment for cases where



the initial PAR score is high. To eliminate this problem, percentage reduction in PAR score is also used. Percentage reduction is an indicator of improvement in treatment for cases where the initial PAR score is high. Percentage reduction indicates success of treatment better than numeric reduction in PAR score in cases with moderate to low pre-treatment PAR scores. Richmond et al. (1992b) illustrated this point by stating,

> "Thus, a change in PAR score from fifty to ten (a reduction of forty) and a change from fifteen to three (a reduction of twelve) both produce an eighty percent reduction, but a much greater numerical improvement in PAR has been achieved in the first instance."

Richmond et al. (1992b), also determined three levels of change in pre-treatment and post-treatment PAR score. The study had a sample of seventy-four PAR calibrated examiners who studied 128 sets of dental models. The examiners recorded the amount of improvement on a nine point scale, nine indicating greatly improved and zero indicating markedly worse. Three additional groups were developed from the median scores, "worse or no different", "improved", or "greatly improved". Discriminant analysis was used to develop linear separations among the three groups. For a case to be considered "greatly improved", the numerical reduction in PAR score had to drop by at least twenty-two points. For a case to be considered as "improved", the percentage reduction must have been at least thirty percent. Cases that met neither criteria were labeled "worse or no different."

Richmond et al. (1992b) indicated that an additional criteria for judging a good or high standard of treatment was the proportion of cases within the "worse or

no different" group. He stated that practitioners should strive for a "worse or no different" percentage of less than five. "Greatly improved" cases should be forty percent or greater. The author also indicated that the mean percentage reduction in total PAR score should be greater than seventy percent. When all of these criteria are met, the practitioner is treating a high percentage of patients with an obvious need for treatment to a high standard.

DeGuzman et al. (1995) reported slightly different percentages for PAR score improvement. In the University of Pittsburgh (U.S.A.) validation study, the authors concluded a PAR score of forty points indicated a severe malocclusion. To achieve a good or high standard of treatment, sixty-five percent of treated cases should fall within the "improved or greatly improved" categories.

## Outcome Studies Using PAR

Kerr and Buchanan, (1993) from the Glasgow Dental Hospital Clinic, used the study models and records of 150 consecutively completed patients treated only with removable appliances. Eighty-nine percent of the cases fit into the "improved" or "greatly improved" categories. The mean percentage reduction in the 150 cases was fifty-two percent.

Several authors have utilized the PAR Index to grade their own treatments (Fox 1993; Richmond 1993). Richmond (1993) completed a personal audit of fifty-one consecutively treated patients. The mean reduction in PAR score was seventy-four percent, eight percent of the cases was "worse or no different", thirty-nine

percent of the cases was "improved", and fifty-three percent of the cases was "greatly improved". The author suggested that all orthodontists complete a personal audit of their first one hundred consecutively treated patients. Fox showed that twelve percent of his first one hundred treated cases was "worse or no different", forty-seven percent was "improved", and forty-one percent was "greatly improved". Fox noted that his limited treatment cases did not show much improvement in PAR score and cautioned readers that the PAR Index might not be sensitive to improvement brought about by limited treatment

O'Brien et al. (1993) studied the analysis of treatment provided by the Hospital Orthodontic Service of England and Wales. The aim of the study was to evaluate the factors that influenced the number of appointments required to complete orthodontic treatment. A sample from seventeen hospital orthodontic departments was selected for a total sample size of 1630 patients. All cases were graded using the PAR Index. The mean pre-treatment score was 28.8, and the mean post-treatment score was 8.27. This resulted in a mean percentage of 67.26%. The authors concluded that the PAR Index is sensitive enough to evaluate differences in treatment outcomes from several orthodontic departments.

O'Brien and Weyant (1993) utilized the same sample as another earlier (O'Brien et al. 1993) study. The authors evaluated the sample to determine the number of visits required to complete orthodontic treatment. The authors concluded that operator experience had little correlation with the number of orthodontic visits.

However, the number of visits was directly proportional to the severity of the malocclusion.

The PAR Index has been used by Stephens et al. (1993) to assess the quality of orthodontic treatment provided by general dentists in England and Wales. General dental practitioners in England and Wales were required to submit pre-treatment study models and models taken at the end of treatment to enable the Dental Estimates Board to send payment. This enabled Stephens et al. (1993) to complete a PAR Index analysis of these cases. The mean percentage reduction in PAR score was 37.9%. Twenty-three percent was "greatly improved" and thirty-eight percent was classified as "worse or no different". The authors determined that PAR score could be used to assess treatment standards but not the reasons for treatment failure.

Vayda et al., (1994) utilized the PAR Index to compare treatment outcomes between class I and class II malocclusions. The sample consisted of 487 dental casts from the University of Pittsburgh School of Dental Medicine. The sample was divided into 176 class I cases and 311 class II cases. The mean initial PAR score was 27.6 for class I malocclusions and 49.1 for class II malocclusions. The mean post-treatment values for class I malocclusions was 7.8 and the mean post-treatment PAR score of the class II malocclusion was 11.9. The respective reduction in PAR score was 68.6% and 74.4%.

Feghali et al. (1995) used the PAR Index to assess the outcome of orthodontic treatment for patients treated in the graduate orthodontic clinic at Case Western

Reserve University (CWRU) in Cleveland, Ohio. The mean pre-treatment PAR score was 34.0 and the mean post-treatment PAR score was 11.0. Results revealed that four percent was classified as "worse or no different", forty-one percent was "improved", and fifty-five percent was "greatly improved". The authors concluded that the graduate orthodontic clinic at CWRU was treating patients to a high standard.

Afsharpanah et al. (1995) used the PAR Index to score one hundred orthodontically untreated subjects from the Bolton Brush Longitudinal Growth Study in Cleveland, Ohio. The aim of this study was to determine the effect of normal growth and development on PAR Index scores between the ages of 12.4-14.4 years. The respective mean PAR scores initial (T-1) and final (T-2) were 18.7 and 16.8. The results revealed that eighty-four percent was "worse or no different", sixteen percent was "improved", and no cases were "greatly improved". The authors concluded that normal growth and development resulted in an improvement in the occlusion in only sixteen percent of cases.

## Treatment Duration

Alger (1988) studied appointment frequency versus treatment time. The sample consisted of seven groups:

1) Thirty non-extraction class I patients
2) Seven non-extraction class II patients
3) Fourteen premolar extraction (upper and lower) first premolars or upper first premolars and lower second premolars

4) Ten patients treated with extraction of upper and lower second premolars

5) Patients with extraction of upper premolars only (either first or second premolars)

6) Twenty-three patients with non-premolar extractions

7) Two patients treated with orthognathic surgery and orthodontics

The total sample was ninety-two patients. The mean treatment duration was 22.01 months. The mean number of appointments was 15.9 per patient.

Fink and Smith (1992) studied the duration of orthodontic treatment. Data was collected for six orthodontic offices from several geographical regions. The sample size was 118 patients. The mean treatment duration was 23.1 months, and the six offices means ranged from 19.4-27.9 months. High correlation coefficients were found for the number of extracted premolars, the number of broken appointments, pre-treatment mandibular plane angle, pre-treatment ANB angle, and pre-treatment Salzmann Index. Multiple regression was used to determine that these components influenced treatment duration.

Vig et al. (1994) utilized the same sample as Vayda et al.(1994) to study the influence of a number of variables on treatment duration. The authors determined that cooperation and compliance by the patient reduces treatment duration for class II patients but not for class I patients. Feghali et al. (1995) studied treatment duration at the graduate orthodontic clinic at Case Western Reserve University and found that the average treatment duration was 32.7 months. No correlations with other variables

were reported.

## Extraction Versus Non-extraction

### Extraction Frequency

Extraction frequency has been studied and researched by many individuals. Calvin Case (1911) wrote that in his practice the frequency of extractions in class I malocclusion was about one in thirty. He also stated that his frequency of extractions in class II cases was about one in every twenty, making the overall extraction percentage about one in twelve. Peck and Peck (1979) defined extraction frequency as a statistical measure describing the number of orthodontic patients having permanent tooth extractions. This number is expressed as a percent of a total sample. In 1966, Charles Tweed reported that his and other practitioners extraction frequency was as high as eighty percent. Peck and Peck (1979) reported extraction frequencies using twelve studies published between 1913 and 1975. They found the extraction frequency was as little as 6.5% from Calvin Case (1913) and as high as 42.1% from Peck and Peck (1975).

A study of orthodontic diagnosis and treatment procedures was authored by Gottlieb et al., (1986) which explored extraction frequency by United States orthodontists. Questionnaires were mailed to all registered orthodontists in 1986. The respondents reported that ninety-five percent of them utilized extractions and their median extraction frequency was 34.9%. The percentage of extraction of upper and lower first bicuspids was 74.4% while extraction of upper and lower second

bicuspids was 5.4%.

Weintraub et al. (1989) conducted a telephone survey of 238 of the 264 registered orthodontists in Michigan. The response rate was 90.2%. The practitioners were asked to estimate their extraction percentage, the median was thirty-nine percent. The estimates ranged from five percent to eighty-seven percent. After completion of the telephone survey, five practices were selected from the extremes. The study showed that the orthodontists estimated extraction rate (telephone survey) and the actual extraction rate (record review) were significantly different. The estimations were underestimated as much as fifteen percent and overestimated as much as twenty percent.

O'Connor (1993) conducted a national survey where fourteen hundred questionnaires were mailed to active orthodontists selected at random from the 1989 Directory of Members of the American Association of Orthodontists. The questionnaire was four pages and consisted of twenty-nine questions designed to elicit information about current (1993) trends in orthodontics compared to orthodontic trends five years prior. The response rate was reported at 58.14% which was 814 returned questionnaires. The mean extraction rate was 29.28% versus the extraction rate five years prior which was 37.74%. The rationale the respondents cited for the reduction in extractions were improved facial esthetics 36.7%, TMJ concerns 14.9%, medicolegal concerns 9.8%, greater stability 8.9%, and other 17.9%. O'Connor (1993) commented in his conclusions, "claims that the extractions of teeth may be

deleterious to the health of the TMJ have had a substantial impact on the rate of extraction."

Sadowsky et al. (1980) conducted a long-term study with a sample of seventy-five patients. The findings indicated that in patients who had undergone orthodontic treatment many years previously for the prevalence of TMJ signs and symptoms was similar to that of a control group of untreated individuals. Sadowsky et al., (1984) indicated that 14.6% of the orthodontic subjects reported TMJ disorders as compared to 21.4% of the untreated subjects. Janson and Hasund (1981) researched functional problems in orthodontic patients out of retention. They reported there was no correlation between extraction and TMD.

Proffit (1994) reviewed consecutive charts at five year intervals from the orthodontic clinic at the University of North Carolina. Fifty consecutive charts were reviewed beginning with 1953 and another series of fifty consecutive charts at every fifth year up to 1993 (450 total records). The records were examined for extraction frequencies. The rate of four first premolar extractions was ten percent in 1953, increased to fifty percent by 1963, and then slowly declined over the next twenty years. The extraction percentage declined significantly by 1993 to almost ten percent. These results were highly significant statistically ($p < 0.001$). The percentage of patients with extractions of either maxillary first premolars alone or maxillary first or second premolars was much less dramatic. The rate of extraction in 1953 was five percent and increased to ten percent by 1963. It then peaked at sixteen percent in

1968 and slowly declined. This study also investigated the prevalence of other combinations of extractions. The definition of "other" extractions was, "a malformed or severely carious tooth, an impossibly impacted canine, a mandibular incisor, a single premolar, and one second and three first premolars" (Proffit 1994). The percentage of patients that fell into this category was approximately sixteen percent from 1953 to 1993. The total extraction frequency for this retrospective study was thirty percent in

1953, seventy-six percent in 1963, and twenty-eight percent in 1993. Proffit (1994) stated four major factors that influenced the decline in extractions:

1) Studies of long term stability showed relapse of dental crowding even after extraction treatment

2) Both Tweed's and Begg's rationale for extractions lost some of their validity

3) Concern was expressed about tempromandibular dysfunction related to the extraction of premolars

4) Technique changes made it easier to manage non-extraction treatment and clinicians noted that the average treatment time for non-extraction cases was shorter than for extraction treatment

## Clinical Trials

### Borderline Extraction Cases

Pacquette et al. (1992) studied the long term effect of extraction versus non-extraction treatment in a group of class II division 1 malocclusions. Sixty-three patients were identified as being susceptible to either non-extraction or extraction treatment, i.e., "borderline cases". Discriminant analysis was used to characterize the

anatomic basis of the extraction or non-extraction decision as employed by the clinicians who did the treatment planning. Ninety-six patients were identified from the Department of Orthodontics at St. Louis University Medical Center as borderline cases. The average post-treatment interval was 14.5 years (range nine to twenty years) the extraction rate was fifty-seven percent. They reported that although the two groups were highly similar with respect to craniofacial characteristics prior to treatment, numerous significant differences were found after treatment. The major differences were greater protrusion of the dentition and increased convexity of the profile in the non-extraction group. Lower incisor irregularity was greater in the extraction group (seventy-three percent) compared to the non-extraction group (fifty-seven percent). The authors concluded that overjet and molar correction were derived mostly from the differential jaw growth rather than actual tooth movement. The pattern of relapse was unrelated to the extraction decision. There was evidence that neither treatment tended to produce a distal displacement of basal bone of the mandible or condyles. Despite a significantly "flatter" profile, the extraction patients proved as likely to view their outcome as an improvement as did the nonextraction patients.

"Clear Cut" Extraction Cases

Luppanapornlarp and Johnston (1993) used the extremes from the Paquette (1992) sample from the Department of Orthodontics at St. Louis University Medical Center. The sample for the study came from the tails of the discriminant analysis

score distribution. One hundred forty-two patients were at the tails of the analysis, from these thirty-three extraction and twenty-nine non-extraction patients were selected. The authors concluded that premolar extraction reduces soft and hard tissue convexity by 2-3 mm, but non-extraction treatment did not effect convexity. The authors also indicated that when growth is finished, clear cut non-extraction patients tend to have "flatter" profiles than extraction patients. In addition, they concluded that in non-extraction treatment, the upper buccal segments are commonly distalized. In contrast, the extraction group had a tendency for the buccal segments to move mesially. There is a tendency for the mandible to be displaced mesially during treatment (extraction more so than non-extraction). Signs and symptoms associated with TMD presented no significant long-term difference between extraction and non-extraction therapy.

## Facial Profile

Drobocky and Smith (1989) studied the change in facial profile during orthodontic treatment with extractions. The authors used records of ten to thirty year old patients chosen at random from five sources. The sources of the sample were patients treated by Charles H. Tweed on file from the Tweed Foundation, patients treated by the Kestling-Rocke group using the Begg technique, patients from two private practices using the 0.022 edgewise appliance, and patients with premolars enucleated at an early age. Cephalometric radiographs were obtained and traced by the same investigator. All pre-treatment and post-treatment cephalometric radiographs were digitized. The Tweed sample differed from the Kestling-Rocke

Begg group and the edgewise appliance groups only for variables related to lower lip protrusion. These variables were labiomental angle, Li to E-line, and LL to Sn-Pog line. The Tweed group demonstrated the greatest amount of lower lip retraction. The nasolabial angle had a mean increase of 5.2° in the total sample. The mean changes in measurements of lip protrusion indicated that the upper and lower lips became less protrusive after treatment. The upper lip moved back 3.4 mm in respect to the E-line and the lower lip moved back 3.6 mm on the average in respect to the E line. Only 8.8% of the 160 patients had a more procumbent upper lip to the Sn-Pog line after treatment. Within the total sample, 13.8% had an excessively flat upper lip and fifteen percent had an excessively flat lower lip. Overall eighty percent of the sample had soft tissue measurements which indicated improvement of the profile, but not a "dished in" appearance.

Young and Smith (1993) investigated the effects of orthodontics on the facial profile in terms of soft tissue. Cephalometric radiographs were used to examine soft tissue profiles of 198 orthodontic patients. Young and Smith studied 198 patients treated with full fixed orthodontics without extractions. Drobocky and Smith (1989) examined changes in facial profiles in patients treated with extractions of four first premolars. The aforementioned studies used quantitative analysis designed to evaluate how often the profile was improved, unchanged, or made worse. Young and Smith (1993) compared their results with the data collected from the Drobocky and Smith article. On average the non-extraction patients had smaller facial changes than

a similar group of extraction patients. The mean difference between extraction and non-extraction patients was six degrees in the nasiolabial angle, 1-2 mm in upper lip protrusion, and 2-3 mm in lower lip protrusion. The mean changes were greater in extraction patients compared to non-extraction patients and the range of individual changes were large for both groups. The type of appliance (Begg versus Tweed versus pre-torqued edgewise) had less influence in non-extraction cases compared to the extraction cases. The quantitative analysis revealed that fifteen percent of both the extraction and non-extraction groups had undesirable facial changes.

Bishara et al. (1995) studied subjects with class II division 1 malocclusion treated with and without the extraction of four first premolars. This study consisted of ninety-one patients, forty-four subjects (twenty-one males and twenty-three females) had four first premolar extractions, and forty-seven subjects (twenty males and twenty-seven females) were treated non-extraction. The results of this study were compared to thirty-five untreated class I subjects. All of the subjects were from the Iowa Longitudinal Facial Growth Study and were matched for sex and age. This study identified six soft tissue landmarks and eighteen hard tissue landmarks present on a lateral cephalogram. The student t test was used to compare the incremental changes between groups from before treatment to after treatment. Comparison between both class II division 1 groups and the untreated class I group revealed that the class II division 1 group finished with a more convex profile. In the male and female extraction groups, there was a significantly greater decrease in the angle of

convexity (G1SnP) and the Holdaway soft tissue angle (Pr-PiNB) as compared to the corresponding non-extraction group. For both male and female subjects, there was a significantly greater decrease in the SNA and NAPog angles in the extraction groups as compared with the non-extraction groups. The males in the extraction group revealed that the upper and lower lips were more protrusive relative to Rickett's esthetic plane. In contrast, the females only revealed lower lip protrusion. The data obtained from this study indicates that lower lip protrusion is an important pre-treatment profile characteristic that influences extraction decision in addition to the preference of tooth size-arch discrepancy. It was observed that the soft tissue and skeletal convexities were straighter in the extraction groups than in the non-extraction groups. The upper and lower lips were more retrusive in the extraction group and more protrusive in the non-extraction group in both sexes.

## Overjet/Overbite

Little et al. (1981) studied sixty-five cases which were a minimum of ten years post-retention, which were previously treated with first premolar extraction. Extractions were performed in late mixed dentition or early permanent dentition. No "sulcus slice" procedures (circumferential supracrestal fibrotomy) were performed in any of these cases. Using dial calipers calibrated to the hundredths of a millimeter, irregularity index, mandibular intercanine width, mandibular arch length, overbite, and overjet were measured. During treatment, overjet decreased significantly in all three angle cases. Pre-treatment overjet was greatest in the class II division 1 patients

($x = 8.96 \pm 0.78$ mm). The class II division 2 cases and the class I cases differed from the class II division 1 cases, their respective means were $x = 4.96 \pm 0.78$ mm and $x = 4.74 \pm 0.35$ mm. Relapse was revealed to occur more often in class II division 1 cases rather than the class II division 2 or class I cases.

Overbite was greatest in the pre-treatment class II division 2 patients ($x = 5.74 \pm 0.67$ mm). The class I patients ($x = 3.48 \pm 0.27$ mm) and the class II division 1 patients ($x = 3.46 \pm 0.38$ mm) differed significantly from the class II division 2 group. The mean overbite decreased significantly for all patients during the active treatment. The greatest decrease in overbite was the class II division 2 ($x = -3.09 \pm 0.84$ mm). Overbite increased significantly in all cases during the post-retention phase ($x = 0.76 \pm 0.15$ mm, $p < 0.001$). An examination of overbite relapse revealed there were no significant differences among the three classes of dental malocclusion. The conclusion from this article was that overjet and overbite treatment and the amount of relapse were not reliable in predicting incisor alignment and stability.

Shields et al. (1985) studied stability and relapse of mandibular anterior alignment and the relationship between overjet and overbite in first premolar extraction cases. The authors studied fifty-four cases which had four first premolar extractions and were treated with traditional edgewise mechanotherapy. The sample consisted of 46.3% of the patients who were class I, 44.4% who were class II division 1, and 9.3% who had class II division 2 malocclusions. Dial calipers calibrated to the hundredth of a millimeter were used to measure overbite and overjet. Cephalometric

analysis with superimpositions was performed on pre-treatment, post-treatment, and post-retention radiographs. The reported results revealed that the maxillary incisor uprighted 9.6° (1-NA). No significant treatment relapse was apparent within the mean data, other than a slight tendency for rebound of the maxillary incisor retraction. No pre-treatment or post-treatment cephalometric variables were able to predict post-retention relapse. Results of the post-retention overbite revealed that seventy-eight percent of the cases which had mandibular incisor intrusion showed extrusion at the time of post-retention. The authors revealed that the mean deep bite subject was skeletally more protrusive (SN-Pg and SNA) and tended to be a "lower angle" case (occlusal plane SN, Y axis-SN, and mandibular plane-SN). Pre-treatment class II molar relationship was a clinically significant predictor of post-treatment bite deepening. However, class I molar relationship did not show any association with post-treatment overbite.

A study by Bishara et al. (1994) examined the effects of extraction and non-extraction orthodontic treatment in class II division 1 patients. The subjects were evaluated over a five year period. Compared to class I males, the class II group had a significantly larger ANB angle, greater overbite, overjet, more protrusive maxillary incisors, and a larger Holdaway soft tissue angle. In females, the class II group had significantly more protrusive maxillary incisors, larger overjet, and a larger Holdaway soft tissue angle in comparison to the class I group. Comparison of the pre-treatment measurements of the subjects treated with and without extraction of first premolars

showed the following; both males and females in the extraction group had more lower lip protrusion and more upper lip protrusion was found in the male extraction group. All treated class II subjects had comparable reductions in both overbite and overjet when compared to the class I group.

Parker et al. (1995) conducted a retrospective study of 132 treated orthodontic cases with at least seventy percent overbite. The sample was divided into sixty-one class I, twenty-seven class II division 1, and forty-four class II division 2. These cases were further subdivided into six groups according to the mechanotherapy. Although there were no statistical differences in the results of the six treatments, there were trends in the results. Anterior bite depth improved an average of 4 mm with a 1-1.5 mm maxillary incisor intrusion. The intericisal angle decreased in all cases as a result of treatment, but most notably in the class II division 2 cases.

## Stability

Riedel (1960) investigated retention and how it relates to stability. The author correctly stated that everything from no retention, whatsoever, to retention permanently has been suggested. Many authors (Riedel, 1960; Bishara et al. 1973; Glenn et al. 1987) have concluded that mandibular intercanine width could be expanded during treatment but could not be maintained long term. Little et al. (1981) completed a study on patients ten years post-retention. The authors indicated that the subjects had varying responses to treatment in regards to sustained mandibular anterior alignment. Common variables often associated with clinical judgment of

mandibular anterior alignment such as initial crowding, age, sex, and angles classification were not significant in predicting outcome. Two thirds of the cases developed some amount of mandibular anterior crowding, the mean was greater than 3.5 mm. Little (1990) published an article which reviewed stability and relapse of dental arch alignment. Sixty-five sets of casts from first premolar extraction patient records were evaluated with a minimum of ten years post-retention. Eighty-nine percent demonstrated clinically unsatisfactory alignment at the post-retention stage. In addition, very few enlarged arches had acceptable long term alignment. Superimposition of cephalometric tracings showed variable direction and amount of molar and incisor change in post-retention. There was evidence of mesial molar movement (migration), as well as lingual movement (tipping) of incisors. Patients pre-treatment arch form was similar to the post-retention arch form, both of which deviated from the post-treatment arch form.

A longitudinal evaluation of the anterior border of dentition was studied by Rossouw et al. (1993). The authors compared the long term stability of mandibular incisors in extraction and non-extraction groups. Expansion of the mandibular arch beyond the original intercanine distance is more likely to lead to relapse in the long term. The authors noted that the intercanine relapse tended to have a smaller distance post-retention than pre-treatment. Rossouw et al. (1993) indicated that expansion of the intercanine distance was a causative factor in mandibular incisor instability.

## Vertical Dimension

Drobocky and Smith (1989) showed that there was an increase in vertical facial height (Sn-Me). The mean increase in vertical facial height for the sample was 2.78 mm. The Begg and Tweed treated patients had a smaller mean increase than the straight wire appliance treated patients. Young and Smith (1993) did a similar soft tissue study but reported on the vertical change of non-extraction treated patients. These patients had an increased lower facial height with a mean increase of 4.17 mm. In addition, Pacquette et al., (1992) and Luppanapornlarp and Johnston (1993) reported that extraction cases only showed an increase in vertical dimension (N-Me).

Chua et al. (1993) completed a study with a sample of 174 patients who were treated at the Orthodontic Department of New York University and private offices of two faculty members. The authors examined the affects of extraction versus non-extraction orthodontic treatment in the growth of lower anterior face height. The sample was divided into eighty-seven class I cases and eighty-seven class II cases with approximately half extraction cases in each group. The authors used adjusted measurements to control for normal growth; therefore, the only factor to account for increase in lower anterior face height would be the orthodontic treatment. The study revealed that both class I and class II extraction subjects had significantly increased lower facial height (ANS-Me). The non-extraction subjects had no increase in lower facial height.

Staggers (1994) studied vertical changes following first premolar extractions. Staggers attempted to validate the claim that premolar extractions causes a decrease in

vertical dimension of occlusion which could lead to TMJ disorders. Records of forty-five class I non-extraction cases and thirty-eight class I extraction cases were evaluated. The results did not support the hypothesis that extractions in conjunction with orthodontic treatment result in a loss of vertical dimension. In both groups, there was a slight increase in mandibular plane angle, as well as extrusion of maxillary and mandibular first molars. A small minority of the total cases (three extraction and four non-extraction) had a decrease in anterior facial height after treatment.

Operator Experience

Stephens, (1985) questioned 139 recent graduates of numerous orthodontic programs to ascertain their level of confidence and level of experience. The respondents were grouped by length of clinical training in hours. Group 1 consisted of training programs with one hundred or less of clinical orthodontic instruction and Group 2 consisted of greater than one hundred hours. The author stated that there was a marked difference in the clinical experience and confidence of those who had treated personal patients the greater part of their clinical course compared with those who had a smaller amount of treatment of personal patients.

Pender and Lovius, (1985) conducted a longitudinal study over three years to monitor the effect of change in the emphasis in clinical orthodontic training program. The orthodontic department altered the training of their residents which allowed them to treat patients over a longer period of time with a greater use of variety with appliances. The authors determined the effect of the students spending more time

treating their own cases obtained an increase in clinical experience in three ways. First, more patients were treated by students. Second, there was an increase in the number of patients seen from the beginning of treatment into retention. Third, there was an increase in the variety and complexity of appliances used to treat those patients. Furthermore, the authors concluded the increase in the experience of the operator would provide a greater awareness of potential problems and the experience to correct those problems.

Fowler, (1990) investigated the perception of ideal bracket location and the effect of recent training and experience upon this variability. Seventy-one clinicians of varying degrees of experience and training in pre-adjusted appliances were divided into three groups. Group 1 consisted of twenty-five clinicians with an average of 6.3 years of experience. Group 2 consisted of twenty-one recently trained clinicians with less than six months of experience. Group 3 consisted of twenty-five final year students with limited experience in the appliance. There was a slight trend for the recently trained clinician to be more consistent and more accurate than the experienced clinician.

Cureton et al. (1993) completed a study which quantitatively assessed headgear compliance. The authors evaluated twenty-eight patients over three consecutive months by three groups of evaluators. Group 1 consisted of two board certified and three board eligible orthodontists. Group 2 consisted of ten orthodontic residents and Group 3 consisted of eleven assistants. The error in the estimated

compliance by the experienced orthodontist group was the least in the study. Both the resident and assistant groups had a statistically significant difference from the orthodontist group in the determination of headgear compliance. Millett and Gordon, (1994) completed a five year clinical study of bond failure with no mix adhesive. The study examined 563 patients bonded with stainless steel brackets. One of the variables examined was the effect of operator experience. Fourteen operators were grouped into three groups of varying experience. The range of bond failure was five to eleven percent. The authors stated the mean failure rates did not differ significantly among the groups. They concluded there was no significant difference in bond failure attributed to operator experience.

The PAR Index literature illustrates the usefulness of this occlusal index in outcome studies and personal audits. The treatment duration literature in the past has led to numerous conclusions. However, these conclusions have not led to a clear cut mean for orthodontic treatment duration. Similarly, the literature on operator experience has not led to a definitive answer to the question: "Is there an affect of operator experience on orthodontic outcome?"

## STATEMENT OF THE HYPOTHESIS

Orthodontists treatment outcomes improve with time.

| | |
|---|---|
| Hypothesis I: | Orthodontic treatment outcome as measured by PAR score improves with increasing experience of the operator. |
| Hypothesis II: | Extraction percentage decreases with increasing experience of the operator. |
| Hypothesis III | Treatment duration decreases with increasing operator experience. |

# METHODS AND MATERIALS

The design of this study was a descriptive, retrospective study. The study sample came from 1,314 treated and completed orthodontic cases executed by a single clinician (Dr. Mark G. Hans, (MGH) Berea, Ohio). The principal investigator (CJR) selected the sample by choosing consecutively finished orthodontic cases one hundred between 1981 and 1986 (T1), one hundred cases between 1988 and 1991 (T2), and one hundred cases between 1995 and 1997 (T3).

Selection criteria were as follows:

1. Absence of dentofacial deformities such as cleft lip or palate
2. Complete records available
3. All cases had dental models in satisfactory condition with no broken teeth or inadequate representation of teeth
4. Completed orthodontic treatment

The first, the middle, as well as the most recent one hundred finished orthodontic cases which met the inclusion criteria were chosen for the study. PAR scores were computed using the pre-treatment and post-treatment models. Cases in the mixed dentition were scored using the guidelines developed at Ohio State University (Beglin and Vig 1997). All patients who fell within the inclusion criteria regardless of age or gender were included in the study. After the initial screening of

pre-treatment and post-treatment dental casts, the following information was abstracted from the dental records:

1. Gender
2. Birthdate
3. Treatment start date
4. Deband/debond date
5. Extraction decision

All the orthodontic cases in the study were completed using 0 .018 pre-angulated, pre-torqued brackets (A-Company, San Diego, California). The cases utilized in the study were subjected to several outcome measures: Extraction percentage, treatment duration, and PAR score. All study models were scored by the principal investigator (CJR) using the PAR Index (Richmond et al. 1992a). The investigator was calibrated in the use of the PAR Index (CWRU January 1997) using a standardized set of models.

The sample of three hundred cases (n = 300) were scored according to the PAR Index criteria described by Richmond (1994). The PAR Index weighting for the study followed the Pittsburgh validation described by DeGuzman et al. (1995). Individual scoring was completed on a custom scoring sheet (courtesy of Roland Feghali et al.1995)(see Appendix 2).

The PAR Index was applied to pre-treatment and post-treatment orthodontic study casts. Scores were assigned to various occlusal traits which were identified in

the malocclusion. The scores from these various occlusal traits were summed to obtain a total which represents the degree a case deviates from normal alignment and occlusion. The difference between the pre-treatment and post-treatment PAR scores indicates the degree of improvement due to orthodontic treatment.

The occlusal traits which compose the PAR Index were upper anterior segment (UAS), right and left buccal occlusion (RBO, LBO), overjet (OJ), overbite (OB), and midline deviation (MID). Upper anterior segment measures the contact displacement from the mesial contact point of the canine on one side to the mesial contact point on the other side. The features recorded were crowding, spacing, and impacted teeth. Right and left buccal occlusion were measured independently. The fit of teeth was scored in three planes of space; antero-posterior, vertical, and transverse. The recording zone was from the canine to the last molar present. Overjet can be positive or negative. The recording zone includes all incisor teeth, but measures the most prominent incisor including anterior crossbite. Overbite records the most prominent overlap or open bite of any of the four upper incisors. Midline deviation measures the difference between the upper and lower dental midlines.

## Statistical Analyses

Means and standard deviations were computed for all continuous variables. The experience of the clinician was calculated by counting the days from July 1, 1981 (i.e., the number of days the clinician (MGH) had been practicing orthodontics) to the date treatment started for the patient. The extraction decision was recorded as a

dichotomous variable. A one way analysis of variance was used to detect differences among groups. The Statistical Package for the Social Sciences (SPSS) for Windows® software (SPSS, Inc., Chicago, Illinois) was used for all statistical analysis.

Treatment outcome was assessed using percentage reduction in weighted PAR scores. The formula used to determine the percentage reduction in weighted PAR score was:

$$\frac{X1 - X2}{X1} \times 100\%$$

where X1 = Pre-treatment PAR Score
X2 = Post-treatment PAR Score

The percentage reduction of each PAR component was determined using the aforementioned formula where X represents UAS, RBO, LBO, OJ, OB, or MID. Analysis of variance (ANOVA) was used to compare the percentage reduction at the three time periods. The Alpha value was set at 0.05.

## Intraexaminer Reliability

Correlation coefficient for thirty double determinations was used to estimate intraoperator reliability. After completion of data collection thirty cases were randomly selected and scored again using the PAR Index. Comparison was made between pre-treatment (Pre-tx 1) versus pre-treatment (Pre-tx 2), post-treatment (Post-tx 1) versus post-treatment (Post-tx 2), and percentage reduction (% RED 1) versus percentage reduction (% RED 2).

# RESULTS

## Total Sample

The total sample (n = 300) included 107 mixed and 193 permanent dentition cases. Forty-seven percent were male and fifty-three percent were female. The average age of the group was fourteen years and one month with a standard deviation of 5.7 years. Eighty-two extraction cases were included in the total sample of which only six were nonpremolar extraction. The average treatment duration was 30.2 ± 12.2 months. The demographics of the sample are given in Table 1.

TABLE 1.--Sample Demographics

| | Number | Pre-treatment Age (yrs) | Standard Deviation | % Female |
|---|---|---|---|---|
| Total | 300 | 14.2 | 5.7 | 53 |
| T1 | 100 | 16.5 | 6.7 | 54 |
| T2 | 100 | 14.2 | 2.8 | 56 |
| T3 | 100 | 12.1 | 5.7 | 50 |

T1 subjects treated during the time period from 1981-1986
T2 subjects treated during the time period from 1988-1991
T3 subjects treated during the time period from 1995-1997

The outcome measures for the sample are given in Table 2.

TABLE 2.--Outcome Measures

| | Extraction Percent | Treatment Duration (mo) | Pretx PAR | Posttx PAR | Percent Reduction |
|---|---|---|---|---|---|
| Total | 27 | 30.2 ± 12.2 | 21.8 ± 9.1 | 5.7 ± 3.5 | 73.9 ± 17.8 |
| T1 | 32 | 28.2 ± 9.32 | 23.1 ± 10.0 | 6.2 ± 4.4 | 73.0 ± 21.0 |
| T2 | 24 | 31.4 ± 11.0 | 21.7 ± 9.5 | 5.4 ± 3.0 | 75.1 ±15.8 |
| T3 | 26 | 31.4 ± 11.1 | 20.4 ± 7.6 | 5.4 ± 3.2 | 73.6 ± 16.1 |

T1 subjects treated during the time period from 1981-1986
T2 subjects treated during the time period from 1988-1991
T3 subjects treated during the time period from 1995-1997

According to Angle's classification criteria, the total group included the following malocclusions (Table 3):

TABLE 3.--Total Sample Angle's Classification

| Class | Percent |
|---|---|
| I | 31 |
| II Division 1 | 39 |
| II Division 2 | 11 |
| II Subdivision Right or Left | 16 |
| III | 4 |

Mean and standard deviation (sd) for the pre-treatment and post-treatment PAR scores, as well as percentage reduction for each component are given in Table 4.

TABLE 4.--Total Sample - Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction

| | Pre-treatment | | Post-treatment | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | %RED |
| PAR Score | 21.3 | 9.1 | 5.2 | 3.5 | 73.9 |
| UAS | 4.4 | 2.9 | 0.4 | 0.7 | 91.3 |
| RBO | 1.6 | 1.3 | 0.8 | 0.7 | 52.5 |
| LBO | 1.4 | 1.1 | 0.8 | 0.6 | 44.0 |
| OJ | 1.3 | 1.1 | 0.1 | 0.4 | 90.2 |
| OB | 1.2 | 0.9 | 0.5 | 0.6 | 58.5 |
| MID | 0.4 | 0.3 | 0.1 | 0.4 | 79.1 |

The total sample classified by age versus PAR score and percentage reduction are in Table 5.

TABLE 5.--Total Sample Age Versus PAR Score and Percentage Reduction

| Age (yrs) | N | Group | Pre-treatment | Post-treatment | % RED |
|---|---|---|---|---|---|
| Under 12 | 101 | T1 + T2 + T3 | 20.4 | 5.9 | 71.0 |
| | 17 | T1 | 20.7 | 6.4 | 68.9 |
| | 32 | T2 | 18.6 | 5.8 | 68.7 |
| | 52 | T3 | 21.7 | 5.8 | 73.1 |
| 12 -15 | 138 | T1 + T2 + T3 | 22.2 | 6.8 | 69.5 |
| | 43 | T1 | 24.4 | 7.6 | 68.9 |
| | 55 | T2 | 23.1 | 6.2 | 73.3 |
| | 40 | T3 | 18.2 | 6.6 | 64.0 |
| 16 - 18 | 30 | 16 - 18 T1 + T2 + T3 | 19.5 | 7.1 | 63.9 |
| | 22 | T1 | 18.8 | 7.8 | 58.6 |
| | 4 | T2 | 24.3 | 5.0 | 79.5 |
| | 4 | T3 | 17.2 | 6.2 | 64.0 |
| 19+ | 31 | 19+ T1 + T2 + T3 | 21.1 | 6.1 | 70.9 |
| | 18 | T1 | 22.0 | 6.0 | 72.9 |
| | 9 | T2 | 18.7 | 6.3 | 66.1 |
| | 4 | T3 | 23.0 | 6.7 | 71.0 |

T1 subjects treated during the time period from 1981-1986
T2 subjects treated during the time period from 1988-1991
T3 subjects treated during the time period from 1995-1997

The total sample classified by age and separated by total sample, T1, T2, and T3 are in Table 6.

TABLE 6.--Total Sample Classified by Age at Pre-treatment

| Age (yrs) | Total % | T1 % | T2 % | T3 % |
|---|---|---|---|---|
| Under 12 | 33.3 | 5.3 | 11.0 | 17.0 |
| 12 - 15 | 49.0 | 17.6 | 18.0 | 13.3 |
| 16 - 18 | 7.6 | 4.3 | 1.7 | 1.7 |
| 19+ | 10.0 | 6.0 | 3.0 | 1.0 |

T1 subjects treated during the time period from 1981-1986
T2 subjects treated during the time period from 1988-1991
T3 subjects treated during the time period from 1995-1997

## T1, T2, and T3

For T1 (n = 100), T2 (n = 100), and T3 (n = 100) means were calculated for age, extraction percentage, and treatment duration. Mean and standard deviation was calculated for PAR components, as well as percentage reduction and permanent and mixed dentition subjects.

## T1

The sample consisted of one hundred subject cases treated between 1982 and 1986 and for which pre-treatment and post-treatment dental casts were PAR scored. The mean pre-treatment age at T1 was sixteen years and six months. The percentage of extractions for the T1 group was thirty-two percent of which two percent were non-premolar extraction. The average treatment duration for the group was 28.2 months. According to Angle's classification criteria, the T1 group included the following malocclusions (Table 7):

TABLE 7.--T1 Angle's Classification

| Class | Percent |
|---|---|
| I | 32 |
| II Division 1 | 42 |
| II Division 2 | 12 |
| II Subdivision Right or Left | 11 |
| III | 3 |

T1 subjects treated during the time period from 1981-1986

Mean and standard deviation (SD) for the T1 pre-treatment and post-treatment PAR scores, as well as percentage reduction for each component are given in Table 8.

TABLE 8.--T1 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction

| | Pre-treatment | | Post-treatment | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | %RED |
| PAR Score | 22.6 | 10.1 | 6.3 | 4.0 | 72.6 |
| UAS | 4.4 | 2.4 | 0.5 | 0.7 | 89.8 |
| RBO | 1.7 | 1.6 | 0.7 | 0.9 | 56.7 |
| LBO | 1.6 | 1.3 | 0.8 | 0.7 | 48.7 |
| OJ | 1.4 | 1.1 | 0.1 | 0.4 | 90.5 |
| OB | 1.2 | 0.9 | 0.5 | 0.6 | 59.2 |
| MID | 0.5 | 0.7 | 0.1 | 0.3 | 85.4 |

T1 subjects treated during the time period from 1981-1986

T2

The sample consisted of one hundred treated cases between 1988 and 1991. The mean age of group T2 was 14.2 years. The percentage of extractions in the T2 group was twenty-four percent, all of which were premolar extractions. The mean treatment duration was 31.4 months. According to Angle's classification criteria, the T2 group included the following malocclusions (Table 9):

TABLE 9.--T2 Angle's Classification

| Class | Percent |
|---|---|
| I | 33 |
| II Division 1 | 37 |
| II Division 2 | 8 |
| II Subdivision Right or Left | 16 |
| III | 6 |

T2 subjects treated during the time period from 1988-1991

Means and standard deviations (sd) for the T2 pre-treatment and post-treatment PAR scores, as well as percentage reduction for each component are given in Table 10.

TABLE 10.--T2 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction

| | Pre-treatment | | Post-treatment | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | %RED |
| PAR Score | 21.2 | 9.4 | 5.0 | 4.3 | 74.8 |
| UAS | 3.8 | 3.0 | 0.3 | 0.6 | 91.2 |
| RBO | 1.6 | 1.3 | 0.8 | 0.6 | 52.2 |
| LBO | 1.4 | 1.1 | 0.8 | 0.5 | 45.5 |
| OJ | 1.3 | 1.2 | 0.1 | 0.3 | 94.8 |
| OB | 1.2 | 0.9 | 0.5 | 0.6 | 60.5 |
| MID | 0.5 | 0.7 | 0.1 | 0.4 | 76.5 |

T2 subjects treated during the time period from 1988-1991

T3

The sample consisted of one hundred cases treated between 1995 and 1997. The mean pre-treatment age of group T3 was 12.1 years. The percentage of extractions in the T3 group was twenty-six percent, of which four percent were non-premolar extractions. The mean treatment duration was $31.4 \pm 9.3$ months. According to Angle's classification criteria the T3 group included the following malocclusions (Table 11):

TABLE 11.--T3 Angle's Classification

| Class | Percent |
|---|---|
| I | 28 |
| II Division 1 | 37 |
| II Division 2 | 14 |
| II Subdivision Right or Left | 20 |
| III | 1 |

T3 subjects treated during the time period from 1995-1997

Means and standard deviations (sd) for the T3 pre-treatment and post-treatment PAR scores, as well as percentage reduction for each component are given in Table 12.

TABLE 12.--T3 Mean and Standard Deviation (SD) for PAR Components; Percentage Reduction

| | Pre-treatment | | Post-treatment | | |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | %RED |
| PAR Score | 20.2 | 7.6 | 5.0 | 3.2 | 73.6 |
| UAS | 5.0 | 3.2 | 0.4 | 0.8 | 84.5 |
| RBO | 1.4 | 1.1 | 0.7 | 0.6 | 52.8 |
| LBO | 1.2 | 0.9 | 0.7 | 0.6 | 43.6 |
| OJ | 1.2 | 1.1 | 0.1 | 0.3 | 92.4 |
| OB | 1.1 | 0.9 | 0.4 | 0.6 | 61.1 |
| MID | 0.3 | 0.6 | 0.1 | 0.3 | 75.0 |

T3 subjects treated during the time period from 1995-1997

The Angle classification versus the treatment duration in months for the total sample are given in Table 13.

TABLE 13.—Angle's Classification Versus Treatment Duration (Months) Total Sample (T1 + T2 + T3)

| Class | Treatment Duration Total | Treatment Duration T1 | Treatment Duration T2 | Treatment Duration T3 |
|---|---|---|---|---|
| I | 27.0 | 24.4 | 28.9 | 27.7 |
| II Division 1 | 31.7 | 27.9 | 33.4 | 34.1 |
| II Division 2 | 33.2 | 38.5 | 30.2 | 30.6 |
| II Subdivision Right or Left | 29.9 | 27.3 | 29.4 | 31.8 |
| III | 31.1 | 30.9 | 31.7 | 29.9 |

T1 subjects treated during the time period from 1981-1986
T2 subjects treated during the time period from 1988-1991
T3 subjects treated during the time period from 1995-1997

The Angle classification versus the PAR score and percentage reduction are given for the total sample in Table 14.

TABLE 14.--Angle's Classification Versus PAR Score and Percentage Reduction

| Class | Pre-treatment | Post-treatment | % RED |
|---|---|---|---|
| I | 18.0 | 5.5 | 69.6 |
| II Division 1 | 22.3 | 4.9 | 77.9 |
| II Division 2 | 22.5 | 5.1 | 77.6 |
| II Subdivision Right or Left | 21.9 | 5.1 | 76.4 |
| III | 33.1 | 6.2 | 81.3 |

The Angle classification versus the PAR score and percentage reduction are given for T1 in Table 15.

TABLE 15.--Classification Versus PAR Score and Percentage Reduction (T1)

| Class | Pre-treatment | Post-treatment | % RED |
|---|---|---|---|
| I | 20.8 | 7.1 | 66.0 |
| II Division 1 | 23.3 | 6.0 | 74.5 |
| II Division 2 | 25.3 | 5.8 | 77.0 |
| II Subdivision Right or Left | 24.2 | 5.8 | 75.9 |
| III | 33.1 | 8.0 | 74.5 |

T1 subjects treated during the time period from 1981-1986

The Angle classification versus the PAR score and percentage reduction are given for T2 in Table 16.

TABLE 16.--Classification Versus PAR Score and Percentage Reduction (T2)

| Class | Pre-treatment | Post-treatment | % RED |
|---|---|---|---|
| I | 18.6 | 6.2 | 66.6 |
| II Division 1 | 22.7 | 4.9 | 78.7 |
| II Division 2 | 21.1 | 5.8 | 72.8 |
| II Subdivision Right or Left | 21.3 | 5.6 | 73.8 |
| III | 33.7 | 4.2 | 87.6 |

T2 subjects treated during the time period from 1988-1991

The Angle classification versus the PAR score and percentage reduction are given for T3 in Table 17.

TABLE 17.--Classification Versus PAR Score and Percentage Reduction (T3)

| Class | Pre-treatment | Post-treatment | % RED |
|---|---|---|---|
| I | 16.4 | 5.8 | 64.4 |
| II Division 1 | 21.1 | 4.7 | 77.8 |
| II Division 2 | 20.8 | 5.3 | 74.4 |
| II Subdivision Right or Left | 22.5 | 6.0 | 73.3 |
| III | 34.0 | 4.2 | 87.6 |

T3 subjects treated during the time period from 1995-1997

## Analysis of Variance

Analysis of variance (ANOVA) was used to examine differences among means. The Alpha value was set at 0.05. Percent reductions in PAR scores between time periods were not statistically significant ($p = 0.6733$). Treatment duration grouped by time periods was not statistically significant ($p = 0.0564$).

The results of data analysis revealed that there was a significant difference between the two means. Statistical significance was determined between class I malocclusion and class II division 1 malocclusion for the PAR score variable ($p = 0.0487$).

## Frequency

Frequency of extraction was calculated using the chi-square method. The frequency of extraction for T1 was thirty-two percent, T2 was twenty-four percent, and T3 was twenty-six percent. Chi-square calculations confirmed there was no statistical difference in extraction frequency among the three time periods.

## Reliability

Intraexaminer reliability was determined by calculating the correlation coefficient. The closer the correlation coefficient results are to one, the more the results can be relied upon with confidence. Results revealed a small amount of examiner bias. Pre-treatment (Pre-tx 1) versus Pre-treatment (Pre-tx 2) was $r = 0.94$. Post-treatment (Post-tx 1) versus Post-treatment (Post-tx 2) was $r = 0.92$. The correlation coefficient for percentage reduction (% RED 1) versus percentage reduction (% RED 2) was 0.93. The results revealed good reliability for the repeat measurements by the principal investigator.

# DISCUSSION

Since the inception of orthodontics as a profession, practitioners have sought to evaluate their finished cases by "putting the plaster on the table". In an effort to make these evaluations more objective, many occlusal indices have been developed. Recently, the PAR Index has gained a moderate amount of popularity in the U.S.A. and Britain as an outcome measure. The purpose of this study was to objectively assess one practitioner's finished cases (outcomes) at three time periods. The outcome measure implemented was, change in PAR score (percentage reduction in PAR score). Secondary variables, extraction percentage and treatment duration, were examined.

Richmond et al. (1992b) wrote there are two ways to assess improvement when using the PAR Index; the numerical reduction in weighted PAR score and the percentage reduction in weighted PAR score. This study used the percentage reduction in weighted PAR score since the numerical reduction requires using the British Session (Richmond et al. 1992a). In addition, the indicator of good or high quality treatment was a mean percentage reduction in the total PAR score of seventy percent or greater. Using the PAR Index criteria, the present study's pre-treatment mean score was $21.8 \pm 9.1$, and the post-treatment mean score was $5.7 \pm 3.5$. The percentage reduction in PAR score for the complete sample was $73.9 \pm 17.8$.

Using Richmond's criteria for success indicates a significant improvement in dento-occlusal relationships, and treatment to a very high standard.

The sample was divided into three time periods. T1, the first one hundred consecutively treated cases, T2, the middle one hundred consecutively treated cases, and T3, the last one hundred consecutively treated cases. The T1 pre-treatment mean score was 23.1 $\pm$ 10.0 and the post-treatment mean score was 6.2 $\pm$ 4.4. The percentage reduction in PAR scores for T1 was 73.0 $\pm$ 21.0. The T2 pre-treatment mean score was 21.7 $\pm$ 9.5 and the post-treatment mean score was 5.4 $\pm$ 3.0. The percentage reduction in PAR score for T2 was 75.1 $\pm$ 15.8. The T3 pre-treatment mean score was 20.4 $\pm$ 7.6 and the post-treatment mean score was 5.4 $\pm$ 3.2. The percentage reduction in PAR score for T3 was 73.6 $\pm$ 16.1. It is evident from the percentage reduction and the post-treatment mean scores that a high standard of treatment was achieved during each time period.

As discussed previously, the PAR Index is composed of six components; upper anterior segment alignment (UAS), right and left buccal occlusion (RBO, LBO), overjet (OJ), overbite (OB), and midline deviation (MID). When evaluating the means of these components in this study, several interesting aspects arise. The pre-treatment mean for upper anterior segment was 4.4, the post-treatment mean was 0.4. Upper anterior segment was the component which showed the greatest percentage improvement, 91.3 percent reduction. The large percent reduction in upper anterior segment reveals that alignment of these teeth was accomplished well

according to PAR Index criteria. Right and left buccal occlusion pre-treatment means were 1.6 and 1.4, respectively. The post-treatment mean score for RBO and LBO were 0.8 and 0.8 respectively. The improvement for both of these components was small; 52.5% and 44.0% reduction, respectively.

Right and left buccal occlusion appeared to have the least amount of correction. However, when compared with the other PAR components right and left buccal occlusion did have the greatest amount of variability. Numerous instances in the study, right and left buccal occlusion worsen after treatment was competed. This is an inherent shortcoming with the PAR Index. Overjet pre-treatment mean score was 1.3 and post-treatment mean score was 0.1. The reduction was 90.2%. Although the percentage reduction is slightly less than that found for the upper anterior segment, the overjet score is weighted or multiplied times five compared to UAS which is not weighted. Therefore, a great reduction in overjet commonly resulted in a high percentage reduction in PAR score. The present overjet weighting greatly influences the reduction in PAR score in class II and class III malocclusions. It is my belief that positive or negative overjet correction is commonly the most difficult aspect of occlusion to correct. In addition, it is my belief that large positive or negative overjet correction is the most dramatic aspect of malocclusion correction, the aspect which realizes the most aesthetic improvement. For these reasons, I believe the weighting for overjet correction is accurate.

The mean pre-treatment and post-treatment score for overbite was 1.2 and 0.5,

respectively. The mean reduction in overbite PAR score led to a 58.5% reduction in this component. The low percentage reduction in overbite is representative of a characteristic evident in numerous post-treatment dental casts in this sample. Many of the cases were finished with a moderate to deep overbite according to PAR criteria. It is my belief that this is a trait of finishing common to the clinician rather than lack of correction. It is evident from this sample that the operator has a tendency to finish cases slightly deeper (greater overbite) than PAR criteria dictates. There is a great amount of variability in practitioners perception of the ideal occlusion, particularly in the depth of overbite. However, the PAR Index criteria does not allow for this variability of perception, which in this sample leads to a low percentage reduction.

The pre-treatment mean score for midline deviation was 0.4 and post-treatment mean score was 0.1 which led to a moderate amount of reduction, 79.1%. A contributing reason for this moderate percentage of reduction is the low pre-treatment score makes high percentage reduction more difficult to achieve. This phenomenon is known as the ceiling effect.

The sample was separated by time periods as discussed previously into time one (T1) the first one hundred completed cases, time two (T2) the middle one hundred completed cases, and time three (T3) the last one hundred treated cases. Analyzing the treatment outcomes reveal trends in the assessed cases. The results reveal that the mean pre-treatment PAR scores decreased through the three time periods. Pre-treatment PAR scores at T1 23.1 $\pm$ 10.0, T2 21.7 $\pm$ 9.5, and T3 20.4 $\pm$

7.6. Similarly post-treatment PAR scores also reduced with time; T1 6.2 $\pm$ 4.4, T2 5.4 $\pm$ 3.0, and T3 5.4 $\pm$ 3.2. This suggests that pre-treatment malocclusion was becoming less severe with time. In addition, the practitioner finished orthodontic cases to a higher success rate according to the PAR Index criteria over time, with the largest distinction between T1 and T2. All pre-treatment component scores with the exception of upper anterior segment, decreased in magnitude over time. It is suspected that the high percentage of mixed dentition cases may contribute heavily to the increase in pre-treatment upper anterior segment scores. It has been reported that scoring mixed dentition cases is questionable and can lead to false scores which are generally higher (Kerr and Buchanan, 1993; Fox 1993). However, in this sample T3 had the greatest amount of mixed dentition cases but showed no increase in PAR scores.

Comparing the sample in terms of Angle's Classification revealed that thirty-two percent of the sample had a class I malocclusion. Class II division 1 malocclusion represented forty-two percent of the sample and class II division 2 malocclusion was twelve percent of the sample. Class II subdivision and class III malocclusion represented eleven and three percent, respectively. According to Proffit and the North Carolina surveys, the stratification of malocclusion (European decent) in the United States is different than the results from the present study. From the Proffit perspective, class I malocclusion is 50-55%, class II malocclusion is 15-20%, and class III represent less than 1% of malocclusions. Thirty percent of the

population is considered to be normal class I occlusions.

Pre-treatment and post-treatment PAR scores, as well as percentage reduction were evaluated by Angle's Classification. There was very little variation when working at the total sample and the subsample. The results showed there were relatively low pre-treatment PAR scores for class I malocclusions. The pre-treatment mean PAR score of 18.0 was treated to a mean posttreatment PAR score of 5.5, which gave a 69.6% reduction. Class I malocclusion had the lowest percentage reduction and the highest mean post-treatment PAR score. It is generally thought by orthodontists that class I malocclusions are easier cases to correct. This possibly led to less attention to detail. This may have accounted for the lower post-treatment PAR score or overjet which is highly weighted and is not a big component of class I.

The class II division 1, class II division 2, and the class II subdivision right or left all had relatively similar pre-treatment PAR scores, post-treatment PAR scores, and percentage reduction. These malocclusions represented the majority of the sample (65%). The practitioner's success rate of 75.6% reduction indicates that he (MGH) has treated these cases to a high standard (Richmond 1992a) if reduction in PAR accurately measures this variable. Class III malocclusion represented a small minority of the sample (three percent). However, the cases deviated the most from ideal occlusion and were the greatest in percent reduction. The mean pre-treatment PAR score for class III malocclusion was 33.1 and corrected to 6.2 and a percentage reduction of 81.3. The conclusion is the practitioner corrects class III malocclusions

very successfully and/or as stated earlier the amount of overjet reduction greatly influenced the percentage reduction or PAR overestimates class III improvement.

Treatment duration is an important variable in any orthodontist's practice. It can have an impact on treatment acceptance, patient cooperation, and the economic viability of the practice. In this study, treatment duration was measured from the time the appliances were placed (band/bond date, beginning of headgear, or beginning of functional appliance) until the day all active appliances were removed (debond date) and retainers placed. For cases treated in two phases, resting phase (time between Phase 1 and Phase 2) was deducted, so only active treatment was included in the measure. The mean treatment duration was calculated at $30.2 \pm 10.9$ months. In order to better understand treatment duration, the cases were separated by malocclusion. Class I malocclusion had the shortest treatment duration, it averaged at 27.0 months for the sample. It was expected that class I malocclusions were completed more rapidly for the following reasons. As stated previously, these cases were less difficult and finished with a slightly higher post-treatment PAR score.

Class II division 1 treatment duration was 31.7 months for the sample. The results are also similar for class II division 2 and class II subdivision right or left. Mean treatment durations for the sample were 33.2 months and 29.9 months. When the sample was examined over time, there was evidence of a trend which shows treatment duration increased slightly. This data suggests the conclusion that treatment duration increased for class II division 2 and class II subdivision right or

left. However, the PAR scores did not decrease accordingly. Although the practitionertook more time to correct the malocclusions, the optimum treatment in terms of PAR score and treatment duration was T2, the middle one hundred cases.

Class III treatment duration mean was 31.1 months, with a low at T3 of 29.8 months. The treatment duration for class III sample was more lengthy possibly due to the increased severity of the malocclusion and increased difficulty in treatment. The treatment duration for class III at T3 is possibly an artifact of only one class III treatment at the time period. To determine an accurate representation of class III treatment duration, it would be necessary to increase the sample size of T3. The percentage reduction is the largest of the malocclusions.

The sample was also classified by age. The starting age of each case was determined by calculating the age at the beginning of treatment from the date of birth and the date of initial active treatment. The sample was separated into four subgroups by dental developmental stage; under twelve years--mixed dentition, twelve to fifteen years--early permanent dentition, sixteen to eighteen years--late permanent dentition, and nineteen and over--adult dentition. The under twelve subgroup comprised 101 cases in the sample. Of the under twelve subgroup T1 consisted of seventeen cases, T2 consisted of thirty-two cases, and T3 consisted of fifty-two cases. For the under twelve subgroup, T3 had the greatest amount of percentage reduction, 71.0%. We can conclude that the increase of two phase treatment, in the under twelve group, either allowed the practitioner to correct the various malocclusions to a high degree or that more severe malocclusions were treated in two phases.

The twelve to fifteen year subgrouping consisted of 138 cases; of which T1 consisted of forty-four cases, T2 consisted of fifty-four cases, and T3 consisted of forty cases. The mean percentage reduction was 69.5%. T2 had a significantly greater reduction in PAR score (73.3) than T1 and T3(68.9 and 64.0). This is possibly due to the T2 mean age which is within the confines of this group. It can be summarized that a greater improvement of PAR score was obtained because the practitioner had greater experience in treating this age group. In addition, the pretreatment PAR score mean was not decreased as in T3.

The sixteen to eighteen subgrouping had the smallest number of cases, thirty in all; T1 consisted of twenty-two cases, T2 consisted of four cases, and T3 four cases. The percentage reduction in PAR score was significantly smaller than the other age groups, percentage reduction was 63.9.

The nineteen plus age subgrouping was also a small number of examined cases, thirty-one in total; T1 consisted of eighteen cases, T2 nine cases, and T3 four cases. The percentage reduction for this subgrouping was 70.9% which was relatively close to the T1 and T3 percentage. However, the T2 percentage reduction dropped to 66.1% due in part by lower pretreatment mean PAR score (18.7) and a relatively high post-treatment PAR score (6.3).

The extraction percentages were determined for T1, T2, and T3. The extraction percentage for T1 was thirty-two percent, T2 was twenty-four percent, and T3 was twenty-six percent. The data revealed that early in the practitioner's

orthodontic practice, extraction was used more frequently. This was possibly due to the higher mean age of the subject pool at the start of treatment. In many cases, an older patient has fewer treatment options; the most effective treatment choice being extraction. Orthodontics, like many things, is subject to patient opinion and professional opinion. Extraction of teeth had decreased in popularity during the T2 time period. The slight two percent increase in extraction percentage is indicative of the continuing trend toward the minimal amount of extraction for orthodontic purposes.

## Limitations of the PAR Index

The PAR Index has many benefits and is an acceptable method to determine orthodontic treatment need and improvement in malocclusion. Irrespective of the benefits of the PAR Index, there are numerous limitations. The PAR Index is a good measure of dento-occlusal change, but does not take into account other targets of orthodontic treatment. This index does not evaluate or measure the change in soft tissue as it relates to orthodontic treatment. Hard tissue, cephalometric values are also not measured. Cephalometric radiographs are often used for orthodontic treatment planning and can also be used to measure change that occurs during treatment.

The PAR Index does not measure other adverse dental conditions such as gingival hypoplasia, gingival recession, decalcification, caries, or TMD symptoms. The PAR Index is highly sensitive for overjet, overbite, and midline changes, but may not be sensitive enough to measure the fine detailing that occurs during finishing

orthodontic cases. The PAR Index has been questioned by several authors in the scoring of mixed dentition cases (Kerr and Buchanan 1993; Fox 1993). However, scoring of mixed dentition has been supported through documentation and verbal communication (Beglin and Vig 1997). The PAR Index guidelines from the Ohio State University Department of Orthodontics, lists the conventions necessary to score mixed dentition cases correctly (O'Brien et al. 1995).

# SUMMARY AND CONCLUSIONS

The outcome of orthodontic therapy from a single practitioner's (MGH) private practice was assessed over time using the Peer Assessment Rating (PAR) Index. Secondary variables, related to outcome, were extraction percentage and the treatment duration. From a population of 1,314 consecutively completed orthodontic cases, a study sample of three hundred was selected. One hundred treated cases were selected from each of the three time periods, the first (T1) and last (T3) one hundred treated cases, as well as the middle (T2) one hundred cases.

Pre-treatment and post-treatment study models were scored using the PAR Index criteria. Additional data were abstracted from patient treatment records to determine the extraction percentage, treatment duration, age, and Angle's Classification. The results of the study showed:

1. The overall percent reduction in PAR score was $73.9 \pm 17.8$, indicating an excellent improvement in dento-occlusal relationships and orthodontic treatment to a high standard.

2. Upper anterior segment (UAS) showed the greatest percentage improvement (91.3%).

3. The pre-treatment malocclusions became less severe over time in this sample as evidence from decreased pre-treatment PAR scores.

4. Class II division 1, class II division 2, and class II subdivision right or left had approximately the same amount of improvement. Class III had the greatest amount of improvement, and class I had less improvement.

5. Class II division I malocclusions showed a greater percentage reduction in PAR when compared to class I malocclusion ($p \leq 0.001$).

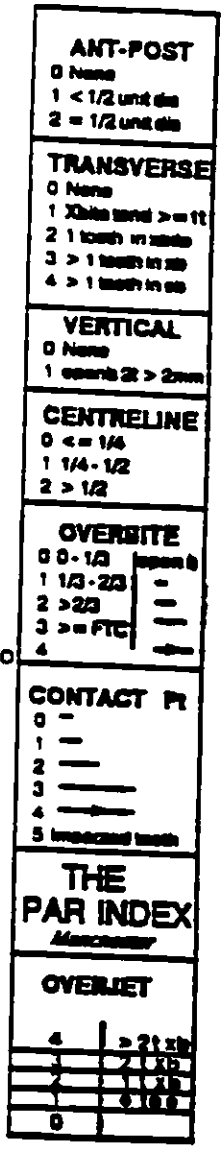
6. Overall treatment duration was 30.2 months. Treatment duration increased slightly over time, due to the increased number of two phase treatments.

7. The practitioner had the lowest treatment duration and the greatest improvement in malocclusion in the twelve to fifteen year age group at T2.

8. Extraction percentages decreased from T1 to T2 and then slightly increased from T2 to T3. Extraction percentage T1 = 32%, T2 = 24%, and T3 = 26%.

There are several possible conclusions to this study. The first is that orthodontist's do not achieve lower PAR scores as they become more experienced. The second is that the PAR Index is not a sensitive enough measure of an orthodontists progress over time. The third is the PAR Index measures treatment outcome, not operator experience.

# 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 anter. 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 (Cleveland) | WEIGHTED PAR SCORE |
|---|---|---|---|---|
| Maxillary Anterior Alignment | Displacement | | | |
| | Inspection | | | |
| | Total | | x 1 = | |
| Right Buccal Occlusion | Antero-posterior | | | |
| | Vertical | | | |
| | Transverse | | | |
| | Total | | x 2 = | |
| Left Buccal Occlusion | Antero-posterior | | | |
| | Vertical | | | |
| | Transverse | | | |
| | Total | | x 2 = | |
| Overjet | Overjet | | | |
| | Anterior Crossbites | | | |
| | Total | | x 6 = | |
| Overbite | Overbite | | | |
| | Openbite | | | |
| | Total | | x 3 = | |
| Centerline | Total | | x 3 = | |
| TOTAL SCORE | | | | |

PRE-TREATMENT

| PAR INDEX COMPONENT | SUB-COMPONENTS | RAW PAR SCORE | WEIGHTING (Cleveland) | WEIGHTED PAR SCORE |
|---|---|---|---|---|
| Maxillary Anterior Alignment | Displacement | | | |
| | Inspection | | | |
| | Total | | x 1 = | |
| Right Buccal Occlusion | Antero-posterior | | | |
| | Vertical | | | |
| | Transverse | | | |
| | Total | | x 2 = | |
| Left Buccal Occlusion | Antero-posterior | | | |
| | Vertical | | | |
| | Transverse | | | |
| | Total | | x 2 = | |
| Overjet | Overjet | | | |
| | Anterior Crossbites | | | |
| | Total | | x 6 = | |
| Overbite | Overbite | | | |
| | Openbite | | | |
| | Total | | x 3 = | |
| Centerline | Total | | x 3 = | |
| TOTAL SCORE | | | | |

POST-TREATMENT

# APPENDIX 3. Data Sheet

| ID No | T1/T2/T3 | Ex/No n | Sex | Age (yrs) | Exp (days) | Tx time | Angle | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | T1 | 0 | f | 19 4 | 442 | 36 | 2 | p | 7 | 2 | 2 | 2 | 3 | 0 | 34 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 79 4 |
| 5 | T1 | 0 | m | 13 1 | 67 | 42 | 2 | p | 4 | 1 | 1 | 3 | 0 | 0 | 23 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 78 3 |
| 2 | T1 | 0 | m | 11 8 | 857 | 18 5 | 0 | p | 5 | 1 | 1 | 1 | 2 | 0 | 20 | 2 | 1 | 1 | 0 | 0 | 0 | 6 | 70 |
| 7 | T1 | 0 | m | 13 6 | 372 | 18 1 | 0 | p | 10 | 1 | 3 | 0 | 0 | 0 | 18 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 72.2 |
| 8 | T1 | 0 | f | 15 3 | 305 | 11 6 | 1 | p | 4 | 4 | 1 | 1 | 1 | 2 | 28 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 67 9 |
| 9 | T1 | 0 | m | 13 9 | 321 | 27 4 | 1 | d | 8 | 1 | 1 | 2 | 2 | 2 | 34 | 2 | 4 | 2 | 0 | 0 | 0 | 15 | 55 9 |
| 11 | T1 | 0 | f | 15 9 | 991 | 29 9 | 0 | p | 7 | 1 | 1 | 1 | 3 | 1 | 26 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 85 7 |
| 12 | T1 | 0 | f | 14 3 | 457 | 28 9 | 1 | p | 5 | 1 | 2 | 0 | 1 | 1 | 17 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 70 6 |
| 23 | T1 | 1 | f | 11 4 | 396 | 17 2 | 0 | d | 3 | 2 | 2 | 3 | 0 | 0 | 26 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 80 8 |
| 25 | T1 | 0 | m | 13 | 1164 | 21 7 | 3 | p | 4 | 1 | 2 | 1 | 2 | 2 | 27 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 85 2 |
| 27 | T1 | 0 | f | 10 4 | 849 | 24 1 | 0 | d | 5 | 0 | 0 | 3 | 1 | 0 | 23 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 82 6 |
| 28 | T1 | 0 | m | 11 2 | 721 | 25 2 | 0 | d | 4 | 1 | 1 | 0 | 1 | 0 | 11 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 81 8 |
| 29 | T1 | 0 | f | 17 3 | 950 | 15 5 | 3 | p | 2 | 1 | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 31 | T1 | 0 | m | 14 2 | 1034 | 28 2 | 0 | p | 8 | 1 | 1 | 2 | 2 | 2 | 34 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 67 7 |
| 32 | T1 | 0 | f | 13 6 | 341 | 30 | 1 | d | 3 | 1 | 1 | 0 | 1 | 0 | 10 | 1 | 2 | 2 | 0 | 0 | 0 | 16 | 60 |
| 33 | T1 | 0 | m | 17 6 | 950 | 15 5 | 3 | p | 2 | 1 | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 34 | T1 | 0 | f | 30 1 | 1022 | 33 1 | 2 | p | 6 | 2 | 2 | 2 | 1 | 1 | 30 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 86 7 |
| 35 | T1 | 1 | f | 14 1 | 880 | 31 3 | 0 | p | 10 | 4 | 4 | 4 | 0 | 0 | 46 | 0 | 1 | 1 | 0 | 1 | 1 | 10 | 78 3 |
| 36 | T1 | 0 | m | 15 1 | 205 | 15 1 | 3 | p | 5 | 0 | 5 | 0 | 2 | 0 | 26 | 1 | 0 | 1 | 0 | 1 | 0 | 9 | 76 9 |
| 37 | T1 | 0 | m | 14 5 | 67 9 | 23 | 0 | p | 4 | 4 | 4 | 0 | 1 | 2 | 29 | 1 | 1 | 0 | 1 | 0 | 0 | 8 | 72 4 |
| 38 | T1 | 0 | f | 14 1 | 848 | 21 9 | 0 | p | 0 | 5 | 1 | 1 | 1 | 0 | 20 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 75 |
| 39 | T1 | 0 | m | 10 6 | 1099 | 23 | 0 | p | 3 | 2 | 1 | 1 | 1 | 0 | 17 | 2 | 0 | 0 | 0 | 1 | 0 | 5 | 70 6 |
| 40 | T1 | 1 | f | 34 3 | 717 | 32.2 | 1 | p | 5 | 2 | 3 | 2 | 1 | 0 | 28 | 1 | 2 | 2 | 0 | 3 | 0 | 8 | 71 4 |
| 41 | T1 | 1 | f | 12.2 | 674 | 27.2 | 1 | d | 4 | 1 | 1 | 2 | 1 | 0 | 21 | 2 | 0 | 0 | 0 | 1 | 0 | 5 | 76 2 |
| 42 | T1 | 1 | f | 13.2 | 830 | 24 1 | 3 | p | 13 | 4 | 4 | 1 | 2 | 1 | 43 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 43 | T1 | 1 | m | 14 1 | 263 | 24 2 | 0 | p | 6 | 2 | 1 | 2 | 1 | 1 | 28 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 82 1 |
| 44 | T1 | 0 | f | 16 3 | 432 | 25 6 | 0 | p | 2 | 1 | 2 | 0 | 1 | 0 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 90 9 |
| 45 | T1 | 0 | m | 13 3 | 973 | 23 5 | 2 | p | 4 | 1 | 1 | 1 | 3 | 0 | 22 | 1 | 1 | 1 | 0 | 1 | 0 | 5 | 63 6 |
| 46 | T1 | 1 | m | 15 8 | 883 | 26 8 | 1 | p | 2 | 4 | 2 | 2 | 1 | 1 | 30 | 1 | 1 | 2 | 1 | 1 | 0 | 15 | 50 |
| 47 | T1 | 0 | m | 22 4 | 554 | 21 | 0 | p | 1 | 0 | 1 | 0 | 2 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 48 | T1 | 1 | m | 14 6 | 630 | 48 | 4 | p | 3 | 6 | 2 | 3 | 2 | 2 | 46 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 91 3 |
| 52 | T1 | 1 | f | 13 | 751 | 24 6 | 1 | p | 5 | 5 | 2 | 2 | 1 | 0 | 32 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 93 8 |
| 54 | T1 | 0 | m | 11 8 | 450 | 26 1 | 1 | d | 3 | 1 | 1 | 1 | 0 | 0 | 12 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 91 7 |
| 55 | T1 | 1 | f | 12.8 | 792 | 25 5 | 2 | d | 2 | 2 | 2 | 1 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 57 | T1 | 0 | f | 25 7 | 861 | 35 8 | 2 | p | 7 | 3 | 3 | 3 | 0 | 0 | 34 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 88 2 |
| 58 | T1 | 0 | m | 14 1 | 856 | 26 9 | 1 | p | 2 | 1 | 0 | 0 | 2 | 1 | 13 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 69 2 |
| 59 | T1 | 0 | m | 22 7 | 1825 | 16 | 1 | p | 1 | 3 | 1 | 0 | 0 | 0 | 9 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 55 6 |
| 60 | T1 | 1 | f | 13 9 | 632 | 31 5 | 2 | p | 4 | 4 | 2 | 2 | 3 | 2 | 41 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 82.9 |
| 61 | T1 | 1 | f | 11 9 | 964 | 27 6 | 1 | p | 10 | 2 | 4 | 3 | 0 | 0 | 37 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 83 8 |
| 64 | T1 | 0 | m | 14 7 | 872 | 28 5 | 1 | p | 4 | 2 | 1 | 0 | 2 | 2 | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 86 4 |
| 66 | T1 | 0 | m | 12.3 | 566 | 17 9 | 0 | p | 4 | 0 | 0 | 0 | 1 | 1 | 10 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 60 |
| 67 | T1 | 0 | m | 12.2 | 610 | 18 3 | 2 | p | 5 | 2 | 2 | 0 | 1 | 0 | 16 | 0 | 1 | 1 | 0 | 0 | 1 | 7 | 56 3 |
| 68 | T1 | 1 | f | 17 2 | 973 | 29 3 | 1 | p | 1 | 1 | 1 | 1 | 1 | 0 | 13 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 30 8 |
| 71 | T1 | 0 | m | 15 3 | 645 | 23 2 | 3 | p | 8 | 1 | 1 | 1 | 2 | 0 | 23 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 87 |
| 75 | T1 | 0 | f | 13 5 | 260 | 26 2 | 1 | p | 3 | 2 | 1 | 3 | 1 | 0 | 27 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 96 3 |
| 76 | T1 | 0 | f | 12 8 | 322 | 35 4 | 2 | p | 5 | 1 | 1 | 1 | 0 | 0 | 14 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 84 3 |
| 78 | T1 | 0 | f | 11.2 | 421 | 32.2 | 0 | d | 1 | 0 | 1 | 2 | 1 | 0 | 16 | 1 | 0 | 0 | 1 | 0 | 1 | 9 | 43 8 |
| 79 | T1 | 0 | m | 16 8 | 380 | 38 2 | 3 | p | 4 | 0 | 2 | 2 | 2 | 0 | 24 | 0 | 0 | 0 | 1 | 1 | 0 | 8 | 66 7 |
| 80 | T1 | 0 | m | 13 9 | 1020 | 15 1 | 0 | p | 4 | 1 | 1 | 1 | 2 | 2 | 25 | 1 | 2 | 2 | 2 | 1 | 0 | 22 | 8 3 |
| 82 | T1 | 0 | f | 13 | 484 | 32.7 | 1 | p | 5 | 2 | 2 | 1 | 1 | 1 | 24 | 1 | 1 | 1 | 1 | 0 | 0 | 10 | 58 3 |
| 83 | T1 | 0 | f | 25 8 | 467 | 29 1 | 0 | p | 5 | 1 | 0 | 0 | 1 | 0 | 10 | 2 | 1 | 1 | 0 | 1 | 0 | 9 | 10 |
| 86 | T1 | 0 | m | 30 1 | 267 | 28 | 1 | p | 5 | 2 | 2 | 1 | 1 | 0 | 21 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 92.5 |
| 88 | T1 | 0 | m | 11 6 | 265 | 36 1 | 2 | d | 3 | 1 | 2 | 0 | 1 | 0 | 12 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 41 7 |
| 89 | T1 | 0 | f | 28 3 | 248 | 30 6 | 0 | p | 4 | 1 | 1 | 1 | 1 | 0 | 16 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 87 5 |
| 90 | T1 | 0 | f | 10 | 428 | 33 9 | 1 | d | 6 | 2 | 1 | 0 | 2 | 0 | 18 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 94 4 |
| 92 | T1 | 1 | m | 10 9 | 472 | 24 8 | 1 | d | 1 | 1 | 1 | 1 | 1 | 1 | 16 | 1 | 1 | 0 | 1 | 1 | 0 | 11 | 31 3 |
| 93 | T1 | 0 | f | 17 2 | 1116 | 9 | 0 | p | 2 | 0 | 1 | 1 | 1 | 0 | 12 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 58 3 |
| 94 | T1 | 0 | f | 15 9 | 889 | 25 2 | 1 | p | 7 | 1 | 1 | 0 | 1 | 0 | 18 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 33 3 |
| 96 | T1 | 0 | m | 13 5 | 620 | 19 9 | 1 | p | 6 | 1 | 3 | 1 | 1 | 0 | 22 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 72 7 |
| 97 | T1 | 1 | f | 14 1 | 365 | 36 1 | 1 | p | 4 | 2 | 1 | 1 | 2 | 0 | 21 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 85 7 |

| ID No | T1/T2/T3 | Exp No | Sex | Age (yrs) | Exp (days) | Tx time | Angle | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 98 | T1 | 0 | m | 12.2 | 273 | 25 9 | 1 | d | 8 | 1 | 1 | 1 | 0 | 0 | 15 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 40 |
| 101 | T1 | 0 | m | 12 | 652 | 33 3 | 0 | d | 8 | 0 | 0 | 3 | 0 | 0 | 23 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 78 3 |
| 103 | T1 | 0 | m | 12.1 | 214 | 36 | 0 | p | 4 | 0 | 1 | 2 | 2 | 1 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 88 |
| 108 | T1 | 0 | m | 14 | 496 | 28 4 | 3 | p | 5 | 1 | 2 | 1 | 2 | 2 | 28 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 85 7 |
| 109 | T1 | 1 | f | 23.2 | 587 | 33 3 | 1 | p | 2 | 1 | 2 | 3 | 3 | 1 | 35 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 85 7 |
| 110 | T1 | 1 | f | 11 2 | 155 | 24 2 | 4 | p | 7 | 1 | 0 | 4 | 0 | 1 | 32 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 78 1 |
| 111 | T1 | 1 | f | 18 4 | 244 | 26 1 | 1 | p | 3 | 2 | 1 | 3 | 1 | 1 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 114 | T1 | 0 | f | 12.1 | 301 | 24 9 | 1 | d | 4 | 1 | 1 | 1 | 0 | 0 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 84 6 |
| 115 | T1 | 0 | m | 21 4 | 591 | 29 5 | 3 | p | 4 | 4 | 1 | 0 | 1 | 0 | 17 | 0 | 0 | 1 | 0 | 1 | 1 | 8 | 53 |
| 116 | T1 | 0 | m | 10 2 | 360 | 61 2 | 3 | d | 2 | 2 | 4 | 2 | 3 | 0 | 33 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 87 9 |
| 119 | T1 | 1 | m | 10 1 | 456 | 106 | 2 | p | 9 | 2 | 2 | 2 | 2 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 123 | T1 | 1 | m | 11 3 | 530 | 33 4 | 1 | d | 4 | 1 | 1 | 1 | 0 | 0 | 13 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 92 3 |
| 125 | T1 | 0 | f | 15 5 | 419 | 40 5 | 0 | p | 10 | 2 | 1 | 0 | 0 | 0 | 18 | 2 | 2 | 2 | 1 | 1 | 0 | 18 | 0 |
| 126 | T1 | 1 | m | 14 2 | 1171 | 21 4 | 1 | p | 6 | 2 | 2 | 3 | 3 | 2 | 44 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 93 2 |
| 133 | T1 | 1 | m | 18 | 963 | 19 2 | 1 | p | 5 | 4 | 2 | 4 | 2 | 1 | 48 | 2 | 2 | 4 | 1 | 1 | 0 | 23 | 50 |
| 136 | T1 | 0 | m | 14 5 | 370 | 28 7 | 1 | p | 0 | 2 | 2 | 2 | 0 | 0 | 18 | 1 | 2 | 0 | 0 | 1 | 0 | 8 | 55 6 |
| 138 | T1 | 0 | f | 20 | 616 | 31 | 1 | p | 4 | 1 | 1 | 1 | 3 | 0 | 22 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 68 2 |
| 153 | T1 | 0 | f | 15 2 | 484 | 22.4 | 0 | p | 3 | 0 | 0 | 1 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 75 |
| 157 | T1 | 1 | m | 11.2 | 106 | 34 9 | 0 | p | 2 | 1 | 0 | 1 | 1 | 0 | 12 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 75 |
| 163 | T1 | 1 | f | 17 4 | 1456 | 17 9 | 0 | p | 5 | 0 | 0 | 0 | 1 | 0 | 8 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 12 5 |
| 170 | T1 | 0 | m | 13 6 | 756 | 23 7 | 0 | p | 5 | 4 | 4 | 2 | 0 | 2 | 37 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 81 1 |
| 171 | T1 | 1 | m | 14 4 | 1341 | 20 6 | 4 | p | 4 | 1 | 1 | 1 | 1 | 0 | 18 | 1 | 1 | 1 | 1 | 1 | 0 | 13 | 18 8 |
| 173 | T1 | 1 | f | 15 9 | 1018 | 30 5 | 0 | p | 5 | 1 | 1 | 2 | 1 | 0 | 22 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 77 3 |
| 175 | T1 | 1 | f | 14 3 | 423 | 20 9 | 0 | p | 2 | 1 | 1 | 3 | 2 | 1 | 30 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 86 7 |
| 178 | T1 | 1 | f | 14 2 | 1318 | 27 4 | 3 | p | 6 | 1 | 2 | 2 | 2 | 1 | 31 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 77 4 |
| 183 | T1 | 0 | f | 28 7 | 908 | 32.1 | 1 | p | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 198 | T1 | 0 | f | 28 1 | 659 | 41 4 | 1 | p | 2 | 2 | 2 | 0 | 0 | 0 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 80 |
| 217 | T1 | 1 | f | 25 5 | 588 | 45 1 | 1 | p | 5 | 1 | 3 | 3 | 3 | 2 | 43 | 0 | 2 | 2 | 0 | 1 | 1 | 14 | 67 4 |
| 228 | T1 | 0 | m | 13 5 | 1078 | 24 8 | 0 | p | 4 | 1 | 0 | 1 | 0 | 0 | 11 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 54 6 |
| 232 | T1 | 0 | m | 12.8 | 1008 | 28 5 | 1 | p | 2 | 2 | 4 | 2 | 2 | 0 | 31 | 2 | 1 | 0 | 0 | 0 | 0 | 4 | 87 1 |
| 233 | T1 | 1 | f | 14 7 | 1033 | 32 | 1 | p | 4 | 2 | 2 | 4 | 1 | 0 | 35 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 83 4 |
| 248 | T1 | 0 | f | 13 | 945 | 30 | 1 | p | 2 | 1 | 1 | 1 | 2 | 0 | 17 | 2 | 1 | 0 | 0 | 0 | 0 | 4 | 76 5 |
| 262 | T1 | 1 | f | 47 5 | 1320 | 25.2 | 2 | p | 5 | 10 | 4 | 0 | 0 | 0 | 19 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 89 5 |
| 264 | T1 | 0 | f | 17 6 | 1210 | 28 8 | 0 | p | 4 | 2 | 2 | 1 | 3 | 0 | 26 | 0 | 4 | 4 | 0 | 3 | 0 | 11 | 57 7 |
| 265 | T1 | 0 | m | 16 8 | 1169 | 24 5 | 1 | p | 3 | 2 | 2 | 1 | 0 | 0 | 14 | 0 | 4 | 2 | 0 | 0 | 0 | 10 | 28 6 |
| 267 | T1 | 1 | f | 16 7 | 979 | 37 | 1 | p | 8 | 1 | 1 | 2 | 1 | 1 | 28 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 92 9 |
| 269 | T1 | 0 | f | 33 9 | 470 | 28 7 | 1 | p | 4 | 1 | 2 | 2 | 2 | 1 | 29 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 82 8 |
| 271 | T1 | 0 | m | 13 2 | 944 | 25 2 | 0 | p | 8 | 1 | 0 | 1 | 2 | 0 | 21 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 71 4 |
| 273 | T1 | 0 | f | 42 6 | 1118 | 24 7 | 1 | p | 2 | 0 | 2 | 3 | 1 | 1 | 27 | 0 | 1 | 1 | 0 | 0 | 0 | 6 | 77 8 |
| 278 | T1 | 0 | f | 16 1 | 1619 | 18 9 | 1 | p | 3 | 1 | 1 | 1 | 2 | 0 | 18 | 1 | 0 | 1 | 0 | 1 | 0 | 6 | 66 7 |
| 662 | T2 | 0 | f | 8 3 | 2057 | 36 5 | 2 | p | 1 | 1 | 1 | 0 | 2 | 0 | 11 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 81 8 |
| 665 | T2 | 1 | m | 8 2 | 2134 | 34 1 | 3 | p | 0 | 0 | 2 | 3 | 0 | 0 | 19 | 2 | 1 | 1 | 0 | 1 | 0 | 8 | 52 6 |
| 666 | T2 | 0 | m | 8 6 | 2357 | 32.4 | 1 | p | 4 | 2 | 1 | 0 | 1 | 0 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 84 6 |
| 667 | T2 | 0 | f | 8 9 | 2176 | 32.3 | 1 | p | 3 | 2 | 2 | 3 | 3 | 0 | 35 | 2 | 1 | 0 | 0 | 1 | 0 | 7 | 80 |
| 670 | T2 | 0 | m | 9.2 | 2337 | 27 3 | 2 | p | 3 | 1 | 2 | 1 | 2 | 0 | 20 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 85 |
| 674 | T2 | 0 | f | 9 4 | 1619 | 27 8 | 1 | d | 1 | 4 | 1 | 2 | 0 | 1 | 24 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 62 5 |
| 677 | T2 | 0 | f | 9 9 | 2247 | 29 7 | 0 | p | 1 | 1 | 1 | 0 | 1 | 1 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 72 7 |
| 681 | T2 | 1 | f | 9 9 | 1981 | 29 2 | 4 | p | 15 | 3 | 4 | 3 | 0 | 2 | 50 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 92 |
| 682 | T2 | 0 | m | 10 | 1604 | 52.3 | 0 | d | 6 | 0 | 0 | 1 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 72 7 |
| 686 | T2 | 0 | m | 10 | 2200 | 33 5 | 0 | d | 6 | 0 | 2 | 0 | 0 | 0 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 80 |
| 687 | T2 | 0 | f | 10 1 | 2462 | 24.1 | 0 | p | 1 | 2 | 0 | 1 | 1 | 0 | 13 | 0 | 1 | 0 | 0 | 2 | 0 | 5 | 61 5 |
| 695 | T2 | 0 | f | 10 2 | 2171 | 35 4 | 0 | d | 2 | 0 | 0 | 1 | 1 | 0 | 10 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 80 |
| 697 | T2 | 1 | f | 10 8 | 2102 | 34 1 | 1 | p | 0 | 1 | 1 | 4 | 1 | 0 | 27 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 81 5 |
| 699 | T2 | 0 | f | 10 6 | 1163 | 30 2 | 4 | d | 8 | 4 | 2 | 2 | 0 | 0 | 28 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 75 |
| 700 | T2 | 0 | m | 10 8 | 2410 | 26 1 | 1 | d | 8 | 1 | 1 | 0 | 1 | 1 | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 87 5 |
| 701 | T2 | 0 | m | 10 8 | 2396 | 28.3 | 0 | p | 4 | 1 | 1 | 2 | 2 | 1 | 27 | 1 | 0 | 0 | 0 | 0 | 1 | 4 | 85 2 |
| 702 | T2 | 1 | f | 10 8 | 2318 | 30 9 | 2 | p | 4 | 2 | 2 | 2 | 1 | 0 | 25 | 1 | 1 | 1 | 1 | 0 | 1 | 13 | 48 |
| 703 | T2 | 0 | f | 10 9 | 2312 | 30 1 | 4 | p | 2 | 1 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 704 | T2 | 0 | f | 11 1 | 1671 | 43 2 | 1 | p | 7 | 1 | 1 | 2 | 1 | 2 | 30 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 83 3 |
| 708 | T2 | 0 | f | 11 1 | 2179 | 35 1 | 0 | p | 1 | 3 | 4 | 0 | 2 | 0 | 21 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 66 7 |
| 710 | T2 | 0 | m | 11 3 | 1861 | 36 7 | 1 | d | 0 | 2 | 2 | 2 | 3 | 1 | 30 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 76 7 |
| 711 | T2 | 0 | m | 11 3 | 2421 | 27 2 | 0 | d | 3 | 0 | 0 | 2 | 3 | 2 | 28 | 0 | 1 | 0 | 0 | 1 | 1 | 8 | 71 4 |
| 712 | T2 | 0 | m | 11 3 | 2458 | 24.3 | 3 | p | 0 | 0 | 2 | 2 | 1 | 0 | 17 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 88 2 |
| 713 | T2 | 0 | f | 11 4 | 1745 | 48 5 | 4 | p | 4 | 4 | 2 | 4 | 0 | 0 | 36 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 86 1 |
| 716 | T2 | 0 | f | 11 4 | 2724 | 18 4 | 0 | p | 2 | 1 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 57 1 |
| 718 | T2 | 0 | m | 11 5 | 1910 | 24 1 | 0 | p | 2 | 1 | 1 | 0 | 2 | 0 | 12 | 0 | 2 | 2 | 0 | 0 | 0 | 8 | 33 |
| 719 | T2 | 0 | f | 11 6 | 2255 | 25 1 | 0 | d | 5 | 1 | 2 | 2 | 1 | 0 | 24 | 1 | 2 | 1 | 0 | 1 | 0 | 10 | 58 3 |
| 722 | T2 | 0 | f | 11 6 | 2618 | 22.5 | 1 | d | 4 | 2 | 1 | 1 | 0 | 0 | 15 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 73 3 |
| 724 | T2 | 1 | m | 11 7 | 2221 | 31 8 | 3 | p | 2 | 1 | 2 | 2 | 1 | 0 | 21 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 76.2 |
| 725 | T2 | 0 | m | 11 7 | 1847 | 32.1 | 2 | d | 1 | 3 | 3 | 0 | 0 | 0 | 13 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 61 5 |

| ID No | T1/T2/T3 | Ex/Non | Sex | Age (yrs) | Exp (days) | Tx time | Angle | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 730 | T2 | 0 | m | 11 8 | 1945 | 36 2 | 3 | p | 1 | 1 | 1 | 3 | 0 | 0 | 20 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 80 |
| 731 | T2 | 1 | f | 11.9 | 2340 | 32.9 | 1 | p | 6 | 2 | 5 | 2 | 2 | 1 | 33 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 94 9 |
| 733 | T2 | 0 | m | 12 | 320 | 110 | 1 | p | 6 | 1 | 2 | 4 | 1 | 0 | 35 | 0 | 2 | 1 | 0 | 1 | 0 | 9 | 74 3 |
| 734 | T2 | 0 | m | 12 | 2978 | 19 6 | 3 | p | 3 | 2 | 1 | 0 | 2 | 2 | 21 | 0 | 1 | 2 | 0 | 0 | 0 | 6 | 74 4 |
| 735 | T2 | 0 | f | 12 | 1458 | 61 7 | 1 | p | 4 | 1 | 1 | 0 | 2 | 1 | 17 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 76 5 |
| 736 | T2 | 0 | m | 12 1 | 2853 | 21 7 | 1 | d | 1 | 1 | 1 | 1 | 1 | 0 | 13 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 76 9 |
| 740 | T2 | 0 | m | 12.2 | 2318 | 33 8 | 0 | p | 11 | 1 | 1 | 0 | 1 | 2 | 24 | 1 | 1 | 0 | 1 | 0 | 0 | 8 | 66 7 |
| 741 | T2 | 1 | m | 12.2 | 2693 | 23 8 | 3 | p | 9 | 2 | 1 | 3 | 1 | 1 | 27 | 2 | 0 | 1 | 0 | 0 | 0 | 4 | 85 2 |
| 744 | T2 | 1 | f | 12 3 | 2696 | 20 8 | 4 | p | 6 | 3 | 4 | 4 | 1 | 2 | 49 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 85 7 |
| 745 | T2 | 1 | f | 12 3 | 2367 | 32 1 | 3 | p | 4 | 4 | 1 | 2 | 1 | 2 | 33 | 1 | 1 | 2 | 0 | 0 | 0 | 7 | 78 8 |
| 746 | T2 | 0 | m | 12 3 | 2335 | 32 2 | 1 | d | 4 | 2 | 1 | 4 | 0 | 1 | 33 | 0 | 0 | 1 | 1 | 1 | 0 | 5 | 84 9 |
| 748 | T2 | 0 | f | 12 3 | 2386 | 32 2 | 1 | d | 6 | 1 | 1 | 1 | 1 | 0 | 18 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 72 2 |
| 755 | T2 | 1 | f | 12 3 | 2196 | 39 4 | 1 | p | 5 | 3 | 2 | 2 | 3 | 2 | 40 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 95 |
| 756 | T2 | 0 | f | 12 3 | 1697 | 36 4 | 1 | d | 2 | 4 | 4 | 1 | 0 | 0 | 23 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 73 9 |
| 757 | T2 | 0 | f | 12 4 | 2696 | 14.5 | 0 | d | 2 | 0 | 1 | 0 | 2 | 0 | 10 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 70 |
| 765 | T2 | 1 | f | 12 4 | 2406 | 30 4 | 0 | d | 7 | 0 | 0 | 1 | 1 | 0 | 15 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 80 |
| 769 | T2 | 0 | f | 12 4 | 2552 | 27 1 | 3 | p | 1 | 2 | 1 | 1 | 2 | 2 | 24 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 83 3 |
| 773 | T2 | 1 | f | 12 5 | 2539 | 28.5 | 3 | p | 1 | 1 | 2 | 0 | 0 | 0 | 7 | 0 | 1 | 1 | 0 | 0 | 0 | 5 | 28 6 |
| 774 | T2 | 0 | m | 12 5 | 3015 | 28 9 | 1 | d | 4 | 1 | 1 | 2 | 1 | 1 | 24 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 83 3 |
| 777 | T2 | 1 | f | 12 6 | 2474 | 32.5 | 0 | p | 7 | 1 | 1 | 2 | 2 | 2 | 33 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 84.9 |
| 779 | T2 | 0 | f | 12 6 | 2262 | 37 1 | 1 | p | 7 | 1 | 2 | 0 | 2 | 2 | 25 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 72 |
| 780 | T2 | 1 | m | 12 7 | 2661 | 24 8 | 0 | d | 4 | 0 | 0 | 1 | 1 | 1 | 15 | 0 | 0 | 1 | 0 | 1 | 1 | 8 | 46 7 |
| 781 | T2 | 0 | m | 12 8 | 2448 | 15 5 | 3 | d | 2 | 0 | 1 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 783 | T2 | 0 | f | 12 8 | 2318 | 29 4 | 1 | d | 3 | 1 | 1 | 1 | 1 | 1 | 18 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 83 3 |
| 787 | T2 | 0 | f | 12 9 | 2540 | 29 4 | 1 | d | 4 | 3 | 1 | 2 | 1 | 2 | 31 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 83 9 |
| 791 | T2 | 1 | m | 12 9 | 2234 | 30 7 | 0 | p | 3 | 1 | 2 | 2 | 1 | 2 | 28 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 75 |
| 794 | T2 | 0 | m | 12 9 | 2525 | 30 5 | 1 | p | 5 | 0 | 1 | 0 | 1 | 0 | 10 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 50 |
| 804 | T2 | 0 | f | 13 | 2998 | 15 1 | 0 | p | 1 | 5 | 1 | 1 | 1 | 0 | 21 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 76 2 |
| 810 | T2 | 1 | f | 13 1 | 2501 | 32 1 | 0 | p | 4 | 1 | 0 | 0 | 2 | 0 | 12 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 75 |
| 813 | T2 | 1 | f | 13 1 | 2183 | 30 3 | 2 | d | 5 | 1 | 1 | 4 | 1 | 0 | 32 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 93 8 |
| 816 | T2 | 0 | m | 13 1 | 3031 | 18.6 | 0 | p | 0 | 0 | 1 | 2 | 1 | 0 | 15 | 1 | 1 | 1 | 0 | 1 | 0 | 8 | 46 7 |
| 817 | T2 | 1 | m | 13.2 | 2428 | 31 1 | 4 | p | 4 | 4 | 4 | 2 | 1 | 0 | 33 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 93 9 |
| 822 | T2 | 0 | f | 13 2 | 2178 | 47 2 | 1 | d | 5 | 2 | 1 | 0 | 1 | 0 | 14 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 64 3 |
| 823 | T2 | 1 | f | 13 2 | 2353 | 37 1 | 3 | d | 2 | 1 | 0 | 0 | 0 | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 85 7 |
| 824 | T2 | 0 | f | 13 2 | 995 | 74 1 | 0 | d | 1 | 0 | 1 | 0 | 1 | 0 | 8 | 0 | 1 | 1 | 0 | 1 | 0 | 9 | 58 |
| 825 | T2 | 0 | m | 13 4 | 2561 | 29.2 | 1 | d | 2 | 4 | 1 | 1 | 1 | 0 | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 95 |
| 826 | T2 | 0 | f | 13 4 | 2985 | 27 4 | 1 | p | 2 | 1 | 1 | 1 | 2 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 827 | T2 | 0 | m | 13 5 | 2852 | 28 6 | 0 | p | 4 | 0 | 1 | 1 | 1 | 1 | 17 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 58 8 |
| 828 | T2 | 0 | f | 13 8 | 2312 | 37 4 | 1 | p | 4 | 1 | 2 | 2 | 1 | 0 | 19 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 73 7 |
| 829 | T2 | 0 | m | 13 9 | 2758 | 25 3 | 0 | p | 4 | 3 | 0 | 0 | 1 | 0 | 13 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 46 2 |
| 831 | T2 | 1 | m | 13 9 | 2712 | 27 7 | 3 | p | 4 | 4 | 5 | 1 | 2 | 1 | 36 | 0 | 1 | 0 | 0 | 1 | 1 | 8 | 77 8 |
| 837 | T2 | 0 | f | 14 1 | 2296 | 42 1 | 1 | p | 12 | 1 | 1 | 0 | 3 | 0 | 25 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 80 |
| 838 | T2 | 0 | f | 14 2 | 2501 | 34 3 | 3 | p | 8 | 2 | 3 | 1 | 0 | 0 | 23 | 1 | 1 | 1 | 1 | 2 | 0 | 16 | 30 4 |
| 839 | T2 | 0 | f | 14 2 | 2980 | 10 1 | 1 | d | 0 | 1 | 1 | 2 | 1 | 0 | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 94 1 |
| 840 | T2 | 0 | f | 14 3 | 2396 | 38 4 | 1 | p | 11 | 3 | 2 | 2 | 0 | 0 | 31 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 83 9 |
| 841 | T2 | 0 | m | 14 5 | 2433 | 25 6 | 1 | d | 0 | 2 | 2 | 2 | 3 | 0 | 27 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 85 2 |
| 843 | T2 | 0 | m | 14 6 | 2609 | 32 | 1 | p | 10 | 2 | 2 | 0 | 1 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 844 | T2 | 0 | f | 14 8 | 2139 | 27 6 | 2 | d | 3 | 1 | 3 | 3 | 1 | 0 | 29 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 75 9 |
| 848 | T2 | 0 | m | 14 8 | 1499 | 28 6 | 3 | d | 2 | 0 | 1 | 1 | 0 | 0 | 9 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 55 6 |
| 848 | T2 | 1 | m | 14 8 | 2777 | 28.1 | 1 | p | 4 | 2 | 2 | 1 | 1 | 1 | 28 | 0 | 0 | 0 | 1 | 1 | 0 | 6 | 78 9 |
| 849 | T2 | 0 | m | 15 1 | 2268 | 42 4 | 0 | p | 4 | 1 | 1 | 0 | 2 | 0 | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 85 7 |
| 853 | T2 | 0 | f | 15 2 | 1915 | 27 9 | 0 | d | 3 | 0 | 0 | 2 | 1 | 1 | 19 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 89 5 |
| 854 | T2 | 0 | f | 15 2 | 2302 | 42 6 | 0 | p | 6 | 0 | 1 | 2 | 0 | 1 | 21 | 1 | 1 | 1 | 0 | 1 | 0 | 8 | 61 9 |
| 855 | T2 | 1 | f | 15 3 | 2183 | 34 5 | 2 | d | 0 | 0 | 0 | 0 | 2 | 1 | 9 | 1 | 2 | 2 | 0 | 0 | 3 | 12 | 0 |
| 857 | T2 | 0 | f | 15 6 | 2701 | 29 1 | 3 | p | 1 | 2 | 1 | 0 | 2 | 2 | 19 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 63 2 |
| 858 | T2 | 0 | f | 15 9 | 2661 | 24 8 | 1 | p | 4 | 2 | 2 | 1 | 3 | 1 | 29 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 89 7 |
| 859 | T2 | 0 | m | 16 1 | 2620 | 27 1 | 1 | p | 2 | 1 | 1 | 0 | 0 | 0 | 9 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 33 3 |
| 860 | T2 | 0 | m | 16 3 | 2818 | 23 8 | 0 | p | 0 | 0 | 1 | 0 | 2 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 75 |
| 862 | T2 | 0 | f | 16 5 | 2849 | 22.4 | 1 | p | 2 | 2 | 2 | 3 | 1 | 0 | 28 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 78 6 |
| 863 | T2 | 1 | m | 16 8 | 710 | 17 7 | 1 | d | 1 | 1 | 1 | 1 | 2 | 0 | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 87 5 |
| 864 | T2 | 0 | f | 17 2 | 2423 | 21 6 | 0 | d | 2 | 2 | 1 | 0 | 3 | 0 | 17 | 0 | 2 | 1 | 0 | 0 | 0 | 6 | 58 8 |
| 866 | T2 | 0 | m | 21 4 | 2849 | 27 7 | 1 | d | 5 | 0 | 1 | 0 | 1 | 0 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 80 |
| 869 | T2 | 0 | f | 23 9 | 2873 | 22.2 | 2 | p | 2 | 6 | 2 | 1 | 3 | 0 | 30 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 76 7 |
| 870 | T2 | 0 | m | 24 4 | 2798 | 27 5 | 1 | d | 2 | 3 | 2 | 0 | 2 | 0 | 18 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 77 8 |
| 871 | T2 | 0 | m | 28 9 | 2479 | 18 3 | 0 | p | 1 | 1 | 1 | 1 | 2 | 0 | 18 | 1 | 0 | 0 | 0 | 0 | 1 | 4 | 75 |
| 874 | T2 | 0 | m | 31 3 | 2514 | 37.2 | 0 | p | 8 | 2 | 2 | 3 | 2 | 0 | 37 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 81 1 |
| 875 | T2 | 0 | f | 33 7 | 2836 | 29 6 | 0 | p | 1 | 5 | 0 | 2 | 0 | 0 | 21 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 90 5 |
| 877 | T2 | 0 | f | 34 1 | 2262 | 46.2 | 3 | d | 10 | 2 | 1 | 0 | 1 | 1 | 22 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 90.9 |
| 879 | T2 | 0 | f | 34 8 | 2667 | 32.3 | 0 | p | 5 | 1 | 1 | 2 | 2 | 0 | 25 | 2 | 2 | 1 | 0 | 3 | 3 | 14 | 44 |
| 887 | T2 | 1 | m | 44 1 | 2851 | 29 6 | 0 | p | 10 | 2 | 1 | 1 | 1 | 0 | 24 | 0 | 3 | 1 | 0 | 0 | 0 | 8 | 66 7 |

| ID No | T1/T2/T3 | Exp/No n | Sex | Age (yrs) | Exp (days) | Tx time | Angle | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1241 | T3 | 0 | m | 5 5 | 3830 | 22.2 | 1 | d | 2 | 1 | 1 | 1 | 1 | 0 | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 85 7 |
| 1242 | T3 | 1 | f | 7 1 | 3834 | 26 | 0 | d | 2 | 1 | 0 | 2 | 0 | 0 | 14 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 85 7 |
| 1243 | T3 | 0 | m | 7 8 | 4134 | 44 3 | 3 | d | 2 | 0 | 2 | 1 | 1 | 0 | 14 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 64 3 |
| 1250 | T3 | 0 | m | 7 9 | 2500 | 25 7 | 3 | d | 5 | 2 | 2 | 1 | 1 | 0 | 21 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 81 |
| 1271 | T3 | 0 | f | 8 1 | 4280 | 20 3 | 0 | p | 4 | 1 | 1 | 1 | 1 | 0 | 16 | 0 | 0 | 0 | 0 | 2 | 0 | 6 | 62.5 |
| 1272 | T3 | 1 | f | 8 1 | 4055 | 25 1 | 1 | p | 4 | 2 | 1 | 2 | 0 | 1 | 23 | 1 | 1 | 1 | 0 | 1 | 1 | 11 | 52.2 |
| 1273 | T3 | 0 | m | 8 4 | 4110 | 25 3 | 2 | d | 9 | 1 | 2 | 2 | 3 | 2 | 40 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 87 5 |
| 1275 | T3 | 0 | f | 8 6 | 3606 | 31 2 | 3 | d | 10 | 1 | 1 | 0 | 2 | 0 | 20 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 65 |
| 1276 | T3 | 0 | f | 8 9 | 4070 | 27 7 | 2 | p | 5 | 2 | 1 | 0 | 1 | 1 | 17 | 1 | 1 | 1 | 0 | 0 | 0 | 5 | 70 6 |
| 1277 | T3 | 0 | f | 9.2 | 4308 | 23 4 | 0 | p | 3 | 1 | 0 | 1 | 1 | 0 | 13 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 69 2 |
| 1278 | T3 | 1 | f | 9.2 | 3650 | 32 1 | 2 | d | 5 | 2 | 1 | 1 | 1 | 0 | 19 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 63 2 |
| 1279 | T3 | 1 | f | 9 3 | 3645 | 28 8 | 3 | p | 16 | 0 | 5 | 1 | 0 | 0 | 31 | 0 | 1 | 1 | 1 | 2 | 0 | 15 | 51 6 |
| 1280 | T3 | 0 | m | 9 3 | 4057 | 25 3 | 0 | d | 4 | 0 | 0 | 0 | 2 | 0 | 10 | 1 | 1 | 1 | 0 | 1 | 0 | 5 | 20 |
| 1281 | T3 | 0 | m | 9 3 | 4114 | 24 2 | 2 | p | 4 | 1 | 1 | 1 | 0 | 0 | 13 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 61 5 |
| 1282 | T3 | 0 | m | 9 5 | 4023 | 22.8 | 0 | d | 2 | 3 | 0 | 0 | 0 | 1 | 11 | 0 | 1 | 0 | 0 | 0 | 1 | 6 | 45 5 |
| 1283 | T3 | 0 | f | 9 5 | 4050 | 29 3 | 0 | d | 2 | 2 | 0 | 0 | 1 | 0 | 9 | 0 | 1 | 1 | 0 | 2 | 0 | 10 | 0 |
| 1284 | T3 | 1 | m | 9 6 | 4038 | 25 2 | 2 | p | 5 | 2 | 2 | 1 | 2 | 0 | 24 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 70 8 |
| 1291 | T3 | 0 | f | 9 6 | 4610 | 23 1 | 2 | p | 4 | 1 | 1 | 0 | 2 | 0 | 14 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 71 4 |
| 1283 | T3 | 0 | m | 9 6 | 4423 | 20 1 | 1 | p | 5 | 0 | 1 | 0 | 1 | 1 | 13 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 76 9 |
| 1284 | T3 | 0 | m | 9 7 | 4493 | 27 2 | 0 | p | 1 | 1 | 1 | 0 | 2 | 0 | 11 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 60 6 |
| 1296 | T3 | 1 | m | 9 8 | 3919 | 28 3 | 4 | p | 4 | 4 | 1 | 4 | 1 | 0 | 37 | 1 | 2 | 2 | 0 | 2 | 0 | 15 | 59 5 |
| 1297 | T3 | 1 | m | 9 9 | 3582 | 31 4 | 4 | d | 6 | 2 | 1 | 2 | 1 | 2 | 31 | 0 | 0 | 2 | 0 | 0 | 0 | 4 | 87 1 |
| 1298 | T3 | 1 | f | 9 9 | 4423 | 28 | 0 | p | 4 | 2 | 1 | 1 | 2 | 1 | 24 | 6 | 0 | 1 | 0 | 0 | 0 | 8 | 66 7 |
| 1299 | T3 | 0 | m | 9 9 | 2849 | 28 8 | 1 | d | 1 | 1 | 1 | 2 | 0 | 0 | 15 | 1 | 2 | 1 | 0 | 1 | 0 | 10 | 33 3 |
| 1300 | T3 | 1 | f | 10 1 | 4101 | 23 2 | 1 | p | 1 | 1 | 1 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 62.5 |
| 1301 | T3 | 0 | f | 10 1 | 3884 | 34 3 | 1 | d | 5 | 1 | 1 | 0 | 1 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 1306 | T3 | 0 | f | 10 1 | 3417 | 27 5 | 2 | d | 3 | 1 | 1 | 2 | 0 | 0 | 17 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 82 4 |
| 1308 | T3 | 0 | m | 10 2 | 4512 | 27 4 | 3 | p | 11 | 1 | 1 | 0 | 1 | 0 | 18 | 0 | 1 | 2 | 0 | 0 | 0 | 6 | 66 7 |
| 1319 | T3 | 0 | m | 10 3 | 4820 | 27 2 | 1 | p | 5 | 2 | 1 | 2 | 1 | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 1320 | T3 | 0 | f | 10 3 | 4231 | 22.3 | 3 | p | 5 | 1 | 1 | 1 | 1 | 1 | 19 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 89 5 |
| 1322 | T3 | 0 | f | 10 4 | 2825 | 30 1 | 1 | d | 9 | 1 | 1 | 2 | 0 | 1 | 29 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 89 5 |
| 1323 | T3 | 0 | f | 10 4 | 4374 | 32.7 | 1 | p | 2 | 3 | 2 | 1 | 2 | 0 | 23 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 78 3 |
| 1326 | T3 | 1 | m | 10 5 | 3903 | 30 | 1 | d | 6 | 1 | 1 | 3 | 0 | 0 | 25 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 92 |
| 1328 | T3 | 1 | f | 10 5 | 4091 | 36 3 | 0 | d | 9 | 0 | 0 | 3 | 1 | 0 | 27 | 1 | 0 | 1 | 1 | 0 | 0 | 8 | 70 4 |
| 1330 | T3 | 1 | f | 10 5 | 3150 | 35 2 | 1 | d | 2 | 0 | 3 | 1 | 1 | 0 | 16 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 43 8 |
| 1332 | T3 | 0 | f | 10 5 | 4269 | 35 1 | 2 | d | 4 | 1 | 2 | 1 | 3 | 0 | 24 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 70 8 |
| 1333 | T3 | 0 | f | 10 8 | 3540 | 29 3 | 0 | d | 3 | 1 | 1 | 2 | 0 | 0 | 17 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 82 4 |
| 1335 | T3 | 0 | f | 10 8 | 3260 | 31 7 | 2 | d | 6 | 2 | 2 | 1 | 3 | 0 | 28 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 75 |
| 1336 | T3 | 1 | m | 10 8 | 3991 | 29 3 | 1 | p | 4 | 3 | 3 | 0 | 0 | 0 | 16 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 87 5 |
| 1344 | T3 | 1 | f | 11 | 4259 | 37 | 0 | d | 3 | 2 | 1 | 1 | 1 | 0 | 17 | 1 | 1 | 0 | 0 | 1 | 0 | 6 | 64 |
| 1350 | T3 | 0 | m | 11 1 | 2441 | 38 6 | 0 | p | 7 | 3 | 2 | 0 | 1 | 0 | 20 | 1 | 1 | 1 | 0 | 1 | 0 | 5 | 60 |
| 1354 | T3 | 0 | m | 11 3 | 3665 | 30 3 | 3 | d | 2 | 0 | 1 | 2 | 2 | 0 | 20 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 80 |
| 1358 | T3 | 0 | m | 11 3 | 3490 | 28 4 | 1 | d | 8 | 2 | 2 | 2 | 1 | 0 | 27 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 92 6 |
| 1357 | T3 | 0 | f | 11 3 | 4532 | 24 2 | 0 | p | 0 | 3 | 0 | 1 | 0 | 2 | 17 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 88 2 |
| 1358 | T3 | 1 | m | 11 5 | 4501 | 32.5 | 1 | p | 5 | 1 | 1 | 1 | 2 | 0 | 20 | 2 | 1 | 0 | 0 | 1 | 0 | 7 | 65 |
| 1369 | T3 | 0 | m | 11 5 | 4496 | 28 4 | 1 | d | 1 | 1 | 1 | 2 | 1 | 0 | 16 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 77 8 |
| 1389 | T3 | 0 | f | 11 5 | 4696 | 29 5 | 3 | p | 4 | 1 | 1 | 0 | 1 | 0 | 11 | 1 | 0 | 1 | 0 | 0 | 1 | 8 | 45 5 |
| 1390 | T3 | 0 | m | 11 5 | 3948 | 32.7 | 0 | d | 8 | 1 | 1 | 2 | 1 | 1 | 28 | 0 | 2 | 2 | 0 | 0 | 0 | 8 | 69 2 |
| 1391 | T3 | 0 | f | 11 7 | 4486 | 30 9 | 1 | p | 2 | 2 | 2 | 2 | 2 | 0 | 28 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 84 6 |
| 1392 | T3 | 0 | f | 11 8 | 4469 | 30 1 | 1 | p | 2 | 2 | 2 | 2 | 2 | 0 | 28 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 80 6 |
| 1393 | T3 | 0 | f | 11 8 | 4864 | 22.3 | 0 | p | 4 | 1 | 1 | 1 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 1394 | T3 | 0 | m | 11 9 | 5038 | 15 7 | 0 | p | 5 | 1 | 0 | 0 | 0 | 0 | 7 | 2 | 1 | 0 | 0 | 0 | 0 | 4 | 42.9 |
| 1394 | T3 | 0 | m | 12.1 | 5110 | 27 2 | 0 | p | 5 | 1 | 0 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 71 4 |
| 1395 | T3 | 0 | m | 12.1 | 4485 | 30 5 | 0 | p | 7 | 1 | 0 | 1 | 1 | 0 | 17 | 1 | 0 | 1 | 1 | 0 | 1 | 11 | 35 3 |
| 1396 | T3 | 0 | f | 12.2 | 4155 | 25 8 | 1 | d | 4 | 1 | 1 | 0 | 2 | 0 | 14 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 85 7 |
| 1398 | T3 | 0 | f | 12.2 | 3386 | 30 9 | 2 | d | 5 | 1 | 1 | 1 | 2 | 0 | 20 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 90 |
| 1399 | T3 | 0 | m | 12.3 | 4837 | 37 8 | 0 | p | 6 | 1 | 1 | 2 | 0 | 0 | 20 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 85 |
| 1400 | T3 | 1 | m | 12.3 | 3795 | 31 3 | 0 | d | 7 | 1 | 2 | 2 | 0 | 0 | 23 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 82.6 |
| 1403 | T3 | 1 | m | 12.4 | 4084 | 42.1 | 3 | p | 8 | 1 | 4 | 0 | 2 | 0 | 23 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 82.6 |
| 1406 | T3 | 0 | f | 12.4 | 4236 | 36 4 | 1 | d | 2 | 1 | 2 | 2 | 2 | 0 | 24 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 83 3 |
| 1407 | T3 | 0 | f | 12.4 | 4585 | 26 | 1 | p | 11 | 2 | 2 | 1 | 1 | 0 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 88 |
| 1408 | T3 | 0 | m | 12.4 | 4340 | 36 3 | 1 | d | 5 | 1 | 1 | 1 | 1 | 1 | 20 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 90 |
| 1409 | T3 | 0 | m | 12.4 | 4841 | 21 7 | 0 | p | 2 | 1 | 1 | 0 | 1 | 0 | 9 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 44 5 |
| 1410 | T3 | 0 | m | 12.5 | 3446 | 32.4 | 1 | d | 1 | 1 | 5 | 1 | 0 | 0 | 18 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 88 9 |
| 1413 | T3 | 0 | m | 12.8 | 4637 | 31 1 | 3 | d | 0 | 2 | 2 | 2 | 4 | 0 | 30 | 1 | 2 | 2 | 0 | 0 | 0 | 9 | 70 |
| 1414 | T3 | 0 | f | 12.8 | 4147 | 35 5 | 1 | d | 12 | 4 | 1 | 0 | 1 | 0 | 25 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 80 |
| 1416 | T3 | 0 | f | 13 1 | 3469 | 66 3 | 1 | p | 12 | 1 | 2 | 1 | 1 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 1420 | T3 | 0 | m | 13 1 | 4432 | 26 9 | 2 | p | 3 | 1 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 71 4 |
| 1422 | T3 | 1 | m | 13 2 | 3324 | 27 3 | 0 | d | 7 | 0 | 0 | 4 | 1 | 0 | 30 | 0 | 0 | 1 | 0 | 1 | 1 | 8 | 73 3 |
| 1423 | T3 | 1 | f | 13 3 | 2437 | 36 7 | 3 | d | 5 | 0 | 1 | 1 | 1 | 0 | 15 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 73 3 |

| ID No | T1/T2/T3 | Ex/No n | Sex | Age (yrs) | Exp (days) | Tx time | Angle | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1425 | T3 | 0 | f | [illegible] | 4364 | 40 1 | 1 | d | 8 | 1 | 1 | 1 | 2 | 0 | 23 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 60 9 |
| 1426 | T3 | 0 | m | 13 3 | 4684 | 29 8 | 1 | p | 8 | 1 | 1 | 1 | 1 | 0 | 20 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 80 |
| 1427 | T3 | 0 | f | 13 4 | 4431 | 38 5 | 1 | d | 12 | 1 | 1 | 0 | 1 | 0 | 19 | 0 | 1 | 0 | 1 | 0 | 0 | 7 | 63 2 |
| 1428 | T3 | 1 | f | 13 5 | 3138 | 79 | 1 | p | 1 | 2 | 2 | 4 | 1 | 0 | 32 | 0 | 1 | 1 | 1 | 0 | 0 | 9 | 71 9 |
| 1430 | T3 | 1 | m | 13 5 | 2203 | 32 6 | 3 | d | 5 | 5 | 0 | 1 | 0 | 2 | 28 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 73 1 |
| 1432 | T3 | 0 | m | 13 7 | 4542 | 35 1 | 3 | d | 11 | 5 | 0 | 2 | 4 | 0 | 48 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 84 8 |
| 1435 | T3 | 0 | f | 13 8 | 4171 | 36 8 | 2 | d | 10 | 1 | 1 | 2 | 1 | 0 | 27 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 85 2 |
| 1441 | T3 | 1 | f | 13 9 | 4372 | 35 2 | 3 | d | 5 | 4 | 1 | 2 | 1 | 0 | 28 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 92 9 |
| 4416 | T3 | 1 | f | 14 | 4113 | 28 1 | 1 | p | 6 | 1 | 1 | 1 | 2 | 0 | 21 | 0 | 1 | 0 | 0 | 1 | 0 | 5 | 76 2 |
| 88003 | T3 | 0 | m | 14 1 | 2395 | 34 1 | 1 | d | 6 | 2 | 2 | 4 | 2 | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 91084 | T3 | 0 | m | 14 4 | 3675 | 36 8 | 1 | d | 1 | 2 | 2 | 1 | 2 | 0 | 20 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 80 |
| 91109 | T3 | 0 | m | 14 4 | 3742 | 41 3 | 3 | d | 6 | 0 | 2 | 2 | 0 | 2 | 26 | 0 | 1 | 1 | 1 | 2 | 0 | 15 | 42 3 |
| 92059 | T3 | 0 | f | 14 4 | 4024 | 51 3 | 2 | d | 4 | 2 | 2 | 1 | 1 | 0 | 20 | 0 | 1 | 1 | 0 | 0 | 0 | 4 | 80 |
| 92099 | T3 | 1 | m | 14 5 | 4458 | 31 4 | 0 | p | 0 | 1 | 1 | 2 | 1 | 1 | 20 | 1 | 0 | 1 | 0 | 0 | 1 | 6 | 70 |
| 93014 | T3 | 0 | f | 14 7 | 4323 | 34 5 | 3 | p | 7 | 3 | 1 | 0 | 2 | 0 | 21 | 0 | 1 | 1 | 0 | 1 | 0 | 7 | 66 7 |
| 93028 | T3 | 0 | f | 14 8 | 4304 | 35 1 | 1 | p | 7 | 1 | 1 | 1 | 2 | 0 | 22 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 90 9 |
| 93035 | T3 | 0 | m | 14 8 | 4288 | 47 | 1 | d | 3 | 1 | 1 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 0 | 1 | 0 | 4 | 60 |
| 93064 | T3 | 0 | m | 14 9 | 4423 | 33 2 | 1 | d | 3 | 1 | 1 | 2 | 1 | 1 | 23 | 0 | 1 | 1 | 1 | 0 | 0 | 8 | 66 9 |
| 93066 | T3 | 0 | f | 15 3 | 3543 | 33 3 | 3 | d | 7 | 1 | 0 | 4 | 0 | 1 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 93076 | T3 | 1 | f | 15 4 | 4462 | 31 1 | 0 | p | 4 | 1 | 1 | 1 | 1 | 0 | 16 | 0 | 1 | 1 | 0 | 0 | 1 | 6 | 62 5 |
| 93094 | T3 | 0 | m | 15 6 | 4491 | 28 3 | 0 | p | 5 | 2 | 1 | 0 | 0 | 0 | 11 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 72 7 |
| 93102 | T3 | 0 | m | 15 8 | 4533 | 32 1 | 1 | d | 3 | 1 | 1 | 2 | 3 | 3 | 29 | 1 | 1 | 1 | 0 | 1 | 0 | 5 | 72 4 |
| 93112 | T3 | 0 | m | 16 3 | 3155 | 52 | 1 | d | 4 | 1 | 1 | 2 | 1 | 0 | 21 | 1 | 0 | 1 | 0 | 1 | 0 | 6 | 71 4 |
| 93156 | T3 | 0 | m | 16 3 | 4127 | 48 | 1 | d | 6 | 1 | 1 | 1 | 1 | 0 | 18 | 0 | 0 | 1 | 0 | 1 | 0 | 5 | 72 2 |
| 94062 | T3 | 0 | f | 16 8 | 4784 | 24 5 | 3 | p | 4 | 2 | 1 | 0 | 1 | 1 | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 87 5 |
| 94332 | T3 | 0 | m | 17 2 | 4518 | 36 4 | 3 | d | 4 | 1 | 1 | 1 | 0 | 1 | 16 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 87 5 |
| 95009 | T3 | 0 | f | 19 1 | 4953 | 14 1 | 0 | p | 3 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 95030 | T3 | 1 | f | 19 8 | 4413 | 36 2 | 0 | p | 14 | 3 | 1 | 0 | 1 | 0 | 25 | 0 | 2 | 2 | 0 | 0 | 0 | 11 | 56 |
| 95034 | T3 | 0 | m | 20 1 | 5017 | 11 8 | 0 | p | 5 | 0 | 1 | 0 | 1 | 0 | 10 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 70 |
| 95078 | T3 | 0 | f | 20 3 | 5149 | 16 2 | 3 | p | 3 | 1 | 1 | 2 | 0 | 0 | 17 | 1 | 1 | 0 | 0 | 1 | 0 | 6 | 64 3 |
| ID No | T1/T2/T3 | Ex/Non | Sex | Age (yrs) | Exp (days) | Tx time | Angle Class | P/D | UAS | RBO | LBO | OJ | OB | CNTR | TOTAL | UAS2 | RBO2 | LBO2 | OJ2 | OB2 | CNTR2 | TOTAL2 | RED |

## Definitions of Data Abbreviations

| | |
|---|---|
| ID No. | Identification number used on model boxes at the private practice of MGH. |
| T1/T2/T3 | Time 1 1981-1986(T1), Time 2 1988 - 1991(T2), Time 3 1995 - 1997(T3) |
| Ex/No | Extraction (1) or nonextraction (0). |
| Sex | Female (f) or male (m). |
| Age | Age in years and months. |
| Exp | Experience in number of days of practice since July 1, 1981. |
| Tx time | Treatment duration in months. |
| Angles | Angles classification. |
| P/D | Permanent or deciduous dentition. |
| UAS | Upper anterior segment. |
| RBO | Right buccal occlusion. |
| LBO | Left buccal occlusion. |
| OJ | Overjet. |
| OB | Overbite |
| TOTAL | Total PAR score. |

## LITERATURE CITED


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

Alger, DW. 1988. Appointment frequency versus treatment time. Am J Orthod Dentofacial 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 Pacquette 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 Dentofacial Orthop 105:444-449.

Beglin, F and KW Vig. May 15, 1997. Personal communication.

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. Am J Orthod Dentofacial Orthop 63:588-595.

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.

Bishara, SE, DM Cummins, JR Jakobsen and JR Zaher. 1995. Dentofacial and soft tissue changes in class II division 1 cases treated with and without extractions. Am J Orthod Dentofacial Orthop 107:28-37.

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 Dentofacial Orthop 1964; 50:660-691).

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

Cureton, SL, FJ Regennitter, and JM Yancey. 1993. Clinical versus quantitative assessment of headgear compliance. Am J Orthod Dentofacial Orthop 104:277-284.

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

DeGuzman, L, K Bahireai, 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 Dentofacial Orthop 107:172-176.

Draker, HL. 1960. Handicapping labio-lingual deviations: a proposed index for public health purposes. Am J Orthod Dentofacial 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 Dentofacial 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 PAR Index. J Dent Res (Abstract 1021) 74:139.

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

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

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

Fowler, PV. 1990. Variations in the perception of ideal bracket location and its implications for the pre-adjusted edgewise appliance. Br J Orthod 17:305-310.

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 Dentofacial Orthop 100:416-420.

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

Grainger, RM. 1967. Orthodontic 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 Dentofacial Orthop 20:401-404.

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

Holman, K. 1995. An Assessment of Extraction Versus Nonextraction Orthodontic Treatment Using The Peer Assessment Rating (PAR) Index, Masters Thesis Case Western Reserve University.

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 Dentofacial Orthop 80:349-364.

Lueke, PE and LE Johnston. 1992. The effect of first premolar extraction and incisor retraction on mandibular position: Testing the central dogma of "functional orthodontics." Am J Orthod Dentofacial 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.

Millet, DT and PH Gordon. 1994. A 5-year clinical review of bond failure with a no-mix adhesive (Right on®). Eur J Orthod 16: 203-211.

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

O'Brien, KD and CM Corkill. 1989. The specialist orthodontic practitioner. 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 Dentofacial 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 20:131-134.

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 Dentofacial Orthop 103:163-170.

Pacquette, 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 Dentofacial 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 Dentofacial Orthop 107:382-393.

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

Pender, N and C Lovius. 1985. Clinical orthodontic experience of Liverpool undergraduates. Br J Orthod 12: 114-116 .

Proffit, WR. 1986. Contemporary Orthodontics St. Louis, Missouri. Mosby Year Book. 6-9.

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 Dentofacial 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 of the anterior border of the dentition. Am J Orthod Dentofacial Orthop 104:146-152.

Sadowsky, C. 1992. The risk of orthodontic treatment for producing temporomandibular mandibular disorders: A literature overview. Am J Orthod Dentofacial Orthop 104:146-152.

Sadowsky, C and E BeGole. 1980. Long-term status of temporomandibular function and functional occlusion after orthodontic treatment. Am J Orthod Dentofacial 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 Dentofacial Orthop 86:386-390.

Salzmann, JA. 1968. Handicapping malocclusion assessment to establish treatment priority. Am J Orthod Dentofacial 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 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 Dentofacial Orthop 87:27-38.

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

Stephens, CD. 1985. Orthodontic experience and clinical confidence of the recent dental graduate. Br Dent J 159:301-303.

Stephens, CD, KJ Drage, S Richmond, WC Shaw, 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 Dentofacial Orthop 59:552-557.

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

Tweed, CH. 1944. Indications for the extraction of teeth in orthodontic procedure. Am J Orthod Dentofacial 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 Dentofacial Orthop 97:45-57.

Weintraub, JA, PS Vig, C Brown and CJ Kowalski. 1989. The prevalence of orthodontic extractions. Am J Orthod Dentofacial 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 Dentofacial 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 Dentofacial Orthop 103:452-458.

49 45CS TH 5128
02/98 00-104-07 GEC