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OUTCOMES ASSESSMENT OF ONE PHASE AND TWO PHASE ORTHODONTIC TREATMENT

by

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Abstract

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Full fixed orthodontic treatment in the permanent dentition is the current gold standard for treating malocclusion. More recently, a two part approach has been popular. This two phase treatment consists of an early mixed dentition phase followed by a second phase of treatment with full fixed appliances. The present study used the PAR index to compare treatment outcome in two hundred patients treated in a single phase with 201 patients treated with the newer two phase approach. All patients were treated by a single practitioner. Date of birth, gender, Angle molar classification, as well as, initial and final treatment dates were recorded. T-test were used to compare the groups with a $p \leq 0.05$ used to assign statistical significance. The mean initial PAR score (T0) for the single phase subjects was 26.2 ± 9.2 and the final mean score (T2) was 3.8 ± 3.2. The percent reduction was $83.8\ \% \pm 16.1$. The mean initial PAR score (T0) for the two phase subjects was 31.9 ± 8.6. The initial mean score at the beginning of the second phase (T1) was 21.9 ± 9.2. The final mean PAR score (T2) was 4.2 ± 4.5. The total percent

reduction for subjects treated in two phases was 85.7% ± 16.5. The average one phase subject initiated treatment at age 13.2 ± 2.0 and was in treatment for an average of 2.7 years ± 0.5. Two phase subjects began treatment at 9.9 ± 1.5 years of age and completed both phases of treatment in 5.7 ± 1.7 years. For one hundred subjects treated in a single phase and one hundred subjects treated in two phases, the extraction rates were 42% and 30%, respectively. There were no significant differences in the percent reduction or final PAR score. Therefore, we conclude that for the subjects studied, single phase treatment produced comparable dental results in less time than did two phase treatment.

DEDICATION

I dedicate this work to:

My close sisters Cynthia, Anne, and Irene for being wonderful role models throughout my life and for inspiring me and showing me their kindness and love.

My parents for helping to motivate me and for supporting and enabling me to fulfill my dream.

My loving partner Greg for sharing this journey with me.

GOD for making this possible.

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INTRODUCTION

Many children are beginning to see the orthodontist at younger ages. This is because of the recent trend in orthodontics to treat patients with two phases of treatment.

By starting treatment when patients are in the early mixed dentition (age 6-7 yrs.), many orthodontists believe they can take advantage of the active growth and achieve a better final result. The first phase of two phase treatment is initiated when the patient is in the mixed dentition. Ideally, there is a definitive end to the first phase and the second phase is begun when the patients have all the permanent teeth. Throughout orthodontic history, orthodontists have commonly treated patients with one phase of treatment typically during the adolescent years. Both methods are used in orthodontic practices. The decision for the orthodontist to recommend two versus one phase of treatment is based upon the needs of the patient and the ability of the orthodontist to provide quality care and an optimum result in one or two phases.

Indices have been developed to measure pre-treatment and post-treatment models. The Index of Orthodontic Treatment Need (IOTN) is utilized in measuring pre-treatment models to assess the need for treatment. The Peer Assessment Rating Index (PAR) is used in measuring pre-treatment and post-treatment models to assess the quality of the orthodontic treatment. Models with ideal occlusion receive

a score of zero, but can be scored as high as fifty or greater for severe malocclusions. Scores for treatment groups can be averaged and compared to evaluate both the quality of the care provided and it compares to other treatment groups.

In order to improve certain malocclusions, an orthodontist may need to extract teeth. Frequently, the four first or second bicuspids are removed. Occasionally, molars, a single lower anterior tooth, or maxillary bicuspids are removed when the orthodontist deems it advantageous. There are no strict guidelines as to when extractions are necessary. Some orthodontists prefer to expand the arch to alleviate crowding rather than the extraction of teeth. Other orthodontists advocate extraction in cases to increase the stability of the final result. The orthodontist can make the decision to extract based on clinical experience. Patients and parents usually prefer to maintain a full compliment of teeth when possible.

Outcome assessment enables an investigator to evaluate effectiveness of orthodontic treatment retrospectively. Totals and percentages can be calculated and compared between groups. Variables, such as the use of certain appliances for specific malocclusions or tendencies to extract teeth in specific treatment groups, can be experienced to gain knowledge of their influence on completed orthodontic cases.

Treatment length is thought to be associated with the severity of the malocclusion. Both parent and patient would prefer shorter treatment time if the

final result were acceptable. Because two phase treatment is initiated at younger ages and involves two distinct phases, the method of treatment lasts longer. This feature is more acceptable for the patient and parent if two phase treatment produced superior outcomes when compared to one phase treatment or was proven necessary to correct severe malocclusions.

The purpose of this study is to determine if there is a difference in treatment result of the dental occlusion between those patients treated with one or two phases of treatment. An improved result, assessed by the final PAR score or elimination of the need for extraction, would support the decision to extend treatment length with two phases.

LITERATURE REVIEW

One Versus Two Phases of Orthodontic Treatment

Every orthodontist wants the best results for their patients. Many orthodontists feel that the way to achieve the best result is to start treatment on patients still in the early mixed dentition. Some orthodontists disagree and maintain that waiting until all the permanent teeth have erupted allows them to achieve optimum results. When treatment is started in the early mixed dentition, orthodontists can utilize two phases of treatment; one that commences when the child has remaining primary dentition and a second, or definitive phase, when the patient has only permanent teeth. During the first phase, skeletal discrepancies as well as malocclusions that can effect the growth of the face, are treated. In Finland, early appliance therapy begins as early as age three with the average start at 5.8 years while the average orthodontic start time is 9.5 years in health centers with a range of 7-13 years (Pietila *et al.*1997). According to a survey in 1991 by the American Association of Orthodontists, 25% of orthodontic patients were treated with two phases and 20-25% of the treated patients were adults. The survey reported that 1.3 million people chose to have orthodontics. If 25% were adults, then approximately 900,000 patients were at a growing age and 25%, or approximately 300,000, would have had two phase treatment (Gottlieb *et al.* 1991).

Interceptive Treatment Versus Early Treatment

Other treatment for those in the mixed dentition, commonly confused with early treatment by dentists and patients, is interceptive or preventive orthodontics. Although both treatments are completed at early ages, they have different goals. It is not the goal of the first phase in orthodontic therapy to align all the teeth and completely correct the malocclusion, but to correct those malocclusions that may influence growth. Interceptive treatment corrects a minor malocclusion in an otherwise normal dentition, eliminating the need for a second phase of treatment (Wagers 1976; Ackerman and Profitt 1980). The dentition is in delicate balance between three main factors: Drifting of the teeth, equilibrium with surrounding tissues like the lips and tongue, and eruption of the teeth. As long as a malocclusion is mainly a result of one of these environmental factors, treatment can be rendered to improve the environment. If the malocclusion is caused by modifications in growth patterns, interceptive treatment will likely to be pointless (Ackerman and Profitt 1980).

Ackerman and Profitt, in 1980, considered the most common discrepancies to be treated by interceptive or preventive therapy were anterior and posterior crossbites, space maintenance or regaining, habits that produce anterior open bite and anterior protrusion with spacing. They discovered, after investigating 4,200 children at the University of Pennsylvania School of Dental Medicine, that of 1,445 patients with primary dentition, only 217 would benefit from interceptive therapy and 1,162 would need complete orthodontic treatment. Therefore, it was not cost

effective to organize orthodontic practices around interceptive orthodontic care as only 15-20% of patients would need such service. Also, with the decrease of caries and the retention of primary teeth, interceptive treatment is becoming less necessary for children in the early mixed dentition, making interceptive treatment less in demand. If treatment on younger patients is a practice goal, early treatment as a portion of two phase treatment would allow a clinician to work on younger children while benefiting a larger percentage of the child population. A similar study was conducted in Burlington with only eighteen successful interceptive treatments out of 1,258 cases. Of those treated, the study revealed that practitioners were successful with crossbite, space maintenance, and thumb sucking cases (Ackerman and Proffit 1980).

Many orthodontists rely on a knowledge of the benefits and disadvantages of early treatment to decide whether to implement it as a treatment method in their offices. The malocclusions recommended for first phase treatment include:

1) crossbite of permanent central incisors (Jarvinen 1981)

2) posterior crossbite leading to an assymetric maxillary growth (Jarvinen 1981)

3) ectopic eruption of the permanent first molars (Jarvinen 1976)

4) supernumerary or missing teeth (Bayardo *et al.* 1979; Wagers 1976)

5) functional open bite (Jarvinen 1979)

6) excessive overjet with an increase risk for trauma (Jarvinen 1979)

Viazis (1995) included early treatment for patients with crowding, deep overbites, and the use of protraction facemasks for hypoplastic maxillas. He believed that withholding treatment could lead to speech or eating problems as well as tooth injury or loss.

Disadvantages of Two Phase Treatment

Treatment Results

In 1995, Gianelly strongly disapproved the use of two phase treatment except for 5-10% of growing patients that had class III malocclusion or crossbites with functional shifts. He felt not losing the space of the deciduous second molars and starting one phase treatment in the late mixed dentition phase, would yield adequate results. Eighty-four percent of anterior crowding can be solved with this approach. Gianelly also compared the result of early treatment with one phase treatment. While Armstrong (1971) used extraoral forces in early treatment to distalize molars 4-7 mm, Gianelly discovered that molars could be distalized 4-6 mm in the late mixed dentition. Both Weislander (1984) and Pancheraz (1979) treated class II with the Herbst appliance. Weislander reported 3.4 mm mandibular growth with 8 and 9 year olds and Pancheraz reported 3.2 mm with 10 and 11 year olds. These difference seem so minor that they do not seem worth the extra time and fee (Gianelly 1995).

There seems to be little argument that class III cases need to be treated early. Tweed (1966) commented that, because class III cases can present themselves in the primary or mixed dentition and become progressively worse, starting treatment early

might avoid more advanced facial deformity. The goals for class III treatment include providing a favorable environment for normal growth, achieving as much maxillary advancement as possible, improving occlusion, and improving esthetics that have psychosocial ramifications (Campbell 1983).

Cost

One common reason for avoiding two phases of treatment is its cost. Pietila *et al.* (1997) found that they were able to advise two phase treatment and start orthodontic treatment early due to the lack of financial barriers in the Finnish dental system. In 1966, Tweed stated that his income had dropped $10,000 when he began treating mixed dentition cases, discouraging others from starting treatment early. However, with proper planning for efficient treatment of mixed dentition cases and thorough explanations to the parents of the treatment fees, much of the negative affect can be avoided (Wagers 1976). Gianelly (1995) argued that early treatment may not be worth the additional fee. Based on the results from Wieslander's study, only one millimeter difference in orthopedic change was noticed between early and late mixed dentition appliance therapy (Weislander 1975). This difference is seemingly not worth the cost of treatment (Gianelly 1995).

Losing the Patient Before Two Phases are Completed

Another reason why orthodontists may hesitate initiating early treatment is because they feel that parents might not bring their child back for the second phase of treatment if they feel the first phase results are satisfactory. Fortunately, only less than 5% do not return for the second phase of treatment. Wagers (1976) suggested

that communicating the need for two phases of treatment to the parents might reduce the number of those not returning for the second phase (Wagers 1976).

Clinical Experience and its Effect on the Treatment Plan

Not all orthodontists have the same training and differ in opinion about the severity of a malocclusion, in diagnosis, treatment planning, and clinical proficiency. Many orthodontists have a non-extraction philosophy and so will need to use a treatment that allows all the teeth to fit. Ruff, in 1970, stated that class II malocclusion should be treated early to avoid extractions while class I cases, with poor facial esthetics, should be treated later when the profile better determines the need for extractions. Brodie (1946) felt that only tooth and alveolar position could be modified when treating a patient. This theory eliminated the use of orthopedic correction with appliances. Stephens *et al.* (1993) found that consultants rarely agreed on the orthodontic treatment plans of forty compared cases submitted by practitioners in England and Wales. They discovered that treatment outcome, as measured by the PAR index, was more effected by the completion of the designed treatment plan and on patient compliance and not the treatment plan itself (Stephens *et al.* 1993). It can be extrapolated that the decision to treat a patient with one phase instead of two may need to be based most on the clinician's ability to achieve the desired result. Also, in Finland, Pietila *et al.* (1992) found that three dentists and an orthodontist were able to agree on which of 260 children needed orthodontic care, but were unable to agree on when it should be started. The orthodontist would have waited to start treatment on forty-four cases and started earlier on twenty cases. The

dentists underestimated the complexity of the cases. Pietila *et al.* proposed that overestimating treatment severity be wiser than underestimation. It was suggested that the added confidence by the orthodontist may have caused the inclination to delay starting treatment (Pietila *et al.* 1992).

Dental Damage Caused by Longer Treatment Durations in Two Phase Cases

Another reason for avoiding two phase treatment is the fear of root resorption. If a patient is in treatment for a longer period of time, it is thought that root resorption is more likey to occur. Wagers (1976) disagreed and stated that root resorption was only a problem in protrusion cases where canines were moved into the roots of the laterals with elastic wear. The mixed dentition cases actually experienced less resorption than permanent dentition cases (Wagers 1976).

In addition to root resorption, other adverse effects of early treatment on dental health need to be considered. King *et al.* (1989) stated that potential periodontal problem can be associated with early treatment. A study on the pulpal response after seventy-two hours of braces recorded a 27% decrease in pulpal response (Hamersky *et al.* 1980).

Kloehn, in 1947, argued that anchorage can be a problem during the first phase of treatment. Because the supporting structures around deciduous and erupting permanent teeth are very dynamic, using them for anchorage may actually lead to unpredictable movement.

Relapse

Even after early treatment is completed, there is concern for significant relapse that requires an extensive retention period before the second phase of treatment. For example, Madone and Ingervall (1984) confirmed that the molar correction with an activator was very unstable. El-Mangoury (1979) discovered that lower canine width expansion was particularly prone to relapse (King *et al.* 1989). Relapse after early treatment raises the question as to whether early treatment is more or less advantageous to patients than one phase treatment. Dugoni *et al.* (1995) studied relapse in twenty-five patients that had two phase treatment. Of the 25, only 19 maintained correction of the lower arch after an average of 9.5 years after retention. All patients experienced arch length deficiencies, and 28% had no decrease in intercanine distance. The study was unable to determine when the dentitions were most unstable during two phase treatment or how to predict instability. However, Reitan (1969) argued that rotated teeth that have been corrected early had more time in their new position and were actually more stable.

Benefits to Two Phase Treatment

Psychosocial Advantages

It has been said that children can be cruel. Ridicule for the appearance of one's teeth can be a motivator of orthodontic care. Shaw *et al.* (1980) discovered that children were most often teased because of height, weight, hair, and teeth. More specifically, Helm *et al.* (1985) found large overjet, crowding, and deep bite were reasons for teasing. Adams (1980) discovered that children as young as three

and four years were effected by physical appearance. Bersheid (1980) reported that children ages seven and eight reacted to, and were able to perceive, attractiveness the same as twenty-five year olds. Bersheid also reported that attractive children were more likely to receive attention from their teachers. Not only do some children psychologically benefit from early orthodontic treatment, but it can be argued that younger children are psychologically ready (Weiss and Eiser 1977).

Younger Ages as an Advantage

Freud developed and labeled the Oedipal period in personality development. During this period children are not particularly cooperative due to internal struggles. Therefore, they are not ideal candidates for orthodontic treatment. Freud felt this period occurred at age five and again at age twelve. Between age six and twelve, when children are interested in learning, they are ready for orthodontics (Stone and Church, 1968). Weiss and Eiser (1977) found that prepubertal children were psychologically ready for orthodontics and more likely to follow instructions regarding wearing their appliances. However, they also found that the younger patients had a tendency to break appliances and miss appointments. Those younger patients that did well in school were also found to be more cooperative with the orthodontist (Burns 1970). Chung and Kerr (1987) discovered that younger patients were likely to be encouraged in attendance and compliance with the appliances by concerned parents. In Germany, Korkhaus (1960) summarized the benefits of early orthopedic correction in younger patients. He felt that appliances like the activator enabled the orthodontist to make improvements in three planes of space

simultaneously that smoothly flow into the following steps in treatment. He also felt that once patients were acclimated to wearing appliances, they were relatively unobtrusive to the patients' daily regimen of school and meals.

Facial Improvements

Better esthetics, which can result in improved self-esteem during formative stages of development, is one significant benefit of initiating early treatment (King *et al.* 1989). In Wagers' (1976) clinical experience with thousands of patients, facial esthetics definitely improved when the patient had early treatment. Brodie (1950) also observed that, even though completed adult cases finished with improved occlusal relationships, they did not have the same improvement in facial esthetics as patients that were started at younger ages. One significant factor that should provoke orthodontists and parents to initiate treatment is severely protrusive anterior teeth. Besides effecting a child's overall facial appearance, protruded teeth need to be repositioned to avoid trauma to the teeth. Chipped or displaced incisors may only further compromise a child's appearance (Wagers 1976).

Taking Advantage of Remaining Growth

One significant reason to start early treatment is to take advantage of remaining growth in attaining the desired facial, skeletal, and dental modification. In 1988, Born *et al.* discovered that the long bones of young growing children were affected by growth spurts that coincided with hormone release when the child relaxed and then slept at night. In 1995, Lee and Profitt revealed that, like the long bones, teeth were affected by hormones and erupt at night. They erupt more in the

evening after 8 PM and may actually intrude in the morning. Tulloch *et al.* (1997) used this growth to their advantage with the use of night headgear in class II patients. They also concluded that any time before adolescence was appropriate for initiating growth modification therapy and that there was no numerical age limit.

Joondeph (1993) agreed that growth modification was benefical for patients at younger ages. He also believed that early treatment on young patients would be particularly advantageous for those patients needing future surgery. Early treatment would prevent natural compensation by the dentition, eliminating the need for decompensational orthodontics and possibly resulting in better surgical outcomes. Samson and Hechtkopf (1988) felt early treatment of surgical patients was worth attempting. It eliminated or decreased the severity of the surgery. If not attempted, the patients undoubtedly needed more comprehensive treatment in the future.

It was observed by Myllarniemi (1970) that older patients had more severe malocclusions. Ricketts (1957) also felt that class II malocclusion, in particular, increased in severity an average of 25% for every year not treated. This can be a reason why a practitioner might want to start treatment early; to treat less difficult problems in younger patients rather than more severe problems in older patients.

Duration of Treatment

In 1987, Chung and Kerr studied early treatment cases which they incorrectly labeled as interceptive treatment. They discovered that two phase treatment had a shorter duration than one phase treatment. The first phase of two phase treatment was found to last an average of fourteen months. The finished two phase cases lasted

an average of 19.3 months, while one phase treatment, in patients older than ten years, lasted an average of 22.1 months. Wagers (1976) discovered that early treatment meant less total treatment time by 5.5 months.

Oral Hygiene

Good oral hygiene is more difficult to achieve with braces and appliances. Early treatment can utilize removeable appliances, theoretically allowing children to better prevent caries. In addition, early treatment can decrease the amount of time in full fixed appliances possibly decreasing the potential for caries development (King *et al.* 1989).

Studies Using Appliances Effectively as a Part of Two Phase Treatment

Class II Studies

Many clinicians and researchers have conducted studies to evaluate the effectiveness of early treatment of class II, division 1 malocclusion. Studies by Tulloch *et al.* (1997) compared the early treatment of class II patients, randomly selected at the University of North Carolina, with overjet values over 7 mm. They divided the patients into those treated by the modified bionator appliance (n = 53), headgear (n = 52), and those that were observed (n = 61). Each group started treatment with class II malocclusion of equal severity. Eighty percent of the patients who wore appliances had a "favorable" response. The skeletal changes, as measured with the SNA, SNB, and ANB angles, showed significant differences between the three groups at $p \leq 0.01$. The results revealed that the two treated groups showed

improvement, but that the correction was achieved by different means. The bionator group showed improvement caused by an increase in the mandibular length and the headgear group showed improvement by restriction of the maxilla.

Pancherz and Anehus-Pancherz (1993) also showed early treatment improvement of class II malocclusions with the Herbst appliance on forty-five patients. Lateral cephalograms were evaluated at four stages: Seven months prior to treatment, seven months after treatment had been initiated, six months post-treatment when occlusion had settled, and an average of 6.4 years post-treatment. It was discovered that the appliance acted similar to a headgear because it caused distal movement of the maxillary molars in 96% of the patients and a clockwise rotation of the occlusal plane in 82% of those examined. These improvements were suggested to possibly eliminate the need for future extractions and allowed the treated patients to continue to grow normally if held properly with retention (Pancherz and Anehus-Pancherz 1993).

Weislander (1984,1993) agreed that the Herbst appliance in conjunction with nightly headgear wear, followed by activator retention, was an effective appliance used to treat class II cases. In 1993, Weislander studied class II children with an average age of eight years and eight months. Eighteen children were in the treatment group and nine in the untreated control group. Cephalometric changes were measured using such angles as ANB and the gonial angle. An activator appliance was used for retention after the Herbst appliance for at least 3-5 years. It was concluded that the maxillary sutural change remained significant post-retention

(at age 17 years 4 months) with an average of 3.5 mm improvement in the sagittal direction. In 1984, Weislander recommended after correction with Herbst appliance and headgear for the first phase of treatment, that there be a resting period until the dental modification, the second phase, was initiated.

Weislander (1975) investigated the use of cervial traction 12-14 hours per day at 10-15 ounces without the Herbst appliance and its effect on two age groups. The groups were divided by skeletal age using the hand wrist radiographs and the dental age was determined by scoring the radiographic assessment of the developing teeth. The younger group had an average age of 8.0 years and a dental score of 23 and the older group 10.5 years and a dental score of 33. The results confirmed that the headgear was effective for early treatment, but that therapy was clearly more effective in the younger patients. Early treatment should be particularly encouraged for severe class II discrepancies (Weislander, 1975).

Successful treatment of a younger class II patient was reported by Wolf (1993). He used high-pull headgear and a tongue crib on a 10.8 year old female patient with a full step molar class II and an anterior open bite. The first phase of treatment lasted 18 months. Second phase records were taken at age 12.5 years. The case was completed with a class I molar. The result would not have been ideal if the clinician delayed treatment and the open bite would have been more difficult to correct, even requiring surgical correction (Wolf 1993).

Baccetti *et al.* (1997) reported monitored 25 class II patients and 22 class I patients through the primary dentition phase and found that those patients with class

II tendencies continued to grow with a class II relationship. The malocclusion of the deciduous dentition was a preview of progressive malocclusion in the permanent dentition. They suggested to consider the risk factors like patient cooperation before treatment in order to predict treatment effectiveness.

MacNamara *et al.* (1985) found success in treating one hundred class II patients in two age groups with average ages of 8.8 years and 11.6 years with the Frankel II appliance. The patients were matched to an untreated control group. Cephalometric changes were recorded. The treatment group for both age groups demonstrated mandibular advancement after two years resulting in an increase in the vertical dimension. The mandibular molar drifted occlusally and the upper anterior teeth were lingually inclined 2 mm.

Class III Studies

Class III patients have been successfully treated with early treatment. In 1997, Chang *et al.* treated a class III patient in two phases using a face mask starting at age nine years. The second phase of treatment required fixed appliances and serial extraction. A successful result was obtained in eight years.

Franchi *et al.* (1997) evaluated forty-five class III patients treated by mandibular retractor therapy. Treatment was initiated at a mean age of 5.6 years. Following comprehensive treatment, they were divided into "successful" and "unsuccessful" groups 9.5 years after the initiation of treatment. Discriminant analysis anabled the investigators to determine which variables related to a positive outcome of early treatment with a mandibular retractor for mandibular prognatism.

They discovered that the inclination of the condyle relative to the cranial base, the angle made by the nasal line and the mandibular line, and the mandibular width at the position of the primary first molars were three of the factors that determined if a class III malocclusion, caused by a prognathic mandible, should be treated successfully using early treatment or if the patient should wait for surgical correction (Franchi *et al.* 1997).

A matched sample of thirty class III patients, average ages six years and below, were studied by Tollaro *et al.* (1996). Cephalometric analysis revealed that those patients treated with the mandibular retractor appliance showed an upward and anterior growth of the condyle that caused a decrease in mandibular length, growth of the maxilla in the sagittal plane, and a maintenance of the vertical dimension. These changes related to the correction of the class III relationship and the improvement of the future growth pattern.

Protraction headgear was proven to aid in early class III correction by protracting the maxilla forward by Shanker *et al.* (1996) They also recorded no vertical or horizontal movement of the cephalometric A-point in twenty-five Chinese children treated at approximately eight years. No relapse was measured in the children, even without retention.

Other Malocclusion Studies

Other malocclusions that could benefit from early treatment include bilateral and unilateral crossbites and open bites. These malocclusions become more of an esthetic and functional problem the longer they remain untreated. An example of

successful early correction of unilateral crossbite was documented by Lindner in 1989. He compared four year old children with unilateral crossbites; 38 treated with selective grinding and 38 observed for natural correction of the malocclusion. Lindner reported 50% of those treated experienced crossbite correction by age nine whereas, only 17% showed crossbite improvement if they were untreated. Early treatment for crossbite cases could possibly prevent future assymetric growth and eliminate, or decrease, the need for comprehensive treatment at an older age.

Arat and Iseri (1992) studied groups of patients treated with fixed appliances and functional appliances to correct skeletal open bites. Groups were treated with Edgewise or Begg appliances and one group was treated with a functional appliance like the bite block. Open bite correction was achieved in all three groups, but the functional group had more mandibular advancement and vertical decrease in the posterior. This differed from the fixed appliance groups that showed a downward and backward rotation of the mandible. The fixed appliance groups started treatment later in puberty than the functional group. This age difference may account for the means of open bite correction.

The PAR Index

Since orthodontists try to improve occlusion, a means of scoring the severity of an original malocclusion and measuring the change due to treatment would be a useful tool to the clinician. Such an index has been developed. The PAR index (Peer Assessment Rating index) was originated in Britain by ten orthodontists called the British Orthodontic Standards Working Party. The group evaluated two hundred

sets of models over the course of six meetings in an attempt to discover the parameters that best evaluated the malocclusion of a particular case. The parameters were measured using a ruler specifically designed with the six factors included in the index. The six factors were:

1) the buccal segment-mesial contact point of the first molar to the distal contact point of the canine

2) anterior segment-the distance between the mesial contact points of the right and left canines, crowding and spacing is measured from the contact points to the occlusal plane

3) buccal occlusion- from the canine to the most posterior molar in the vertical, transverse, and anterior-posterior directions

4) overjet- from the labial surface of the most prominent incisor

5) overbite- amount of lower lateral coverage by the upper centrals or the amount of open bite

6) centerline- distance of the upper midline from the lower midline

Buccal segments, anterior segments, and buccal occlusion were measured separately for upper and lower and right and left. All the factors were scored individually and then added for the total PAR score. Scores closest to zero represent patients with more ideal occlusion. Most scores do not exceed fifty. Pre-treatment and post-treatment models can be scored and the difference represents the change due to orthodontic treatment (Richmond *et al.* 1992a).

Although PAR scores can measure the amount of improvement in a dental malocclusion, it is helpful to determine how much of a change in the PAR score can be considered a "great" (clinically significant) improvement. Richmond *et al.*

(1992b) conducted a study with 128 pairs of pre-treatment and post-treatment models that were analyzed by 74 examiners. The sets of models were graded on a linear scale 0 being markedly worse and 8 being greatly improved. Discriminant analysis was used to relate the graded pairs to their PAR scores. This enabled the investigators to discover a minimum PAR score associated with improvement from pre-treatment to post-treatment. A decrease in PAR score of 22 was considered a "great improvement". A reduction of the PAR score of 30% was considered "improved". A reduction of 70% indicated a high level of care and was established as the "benchmark of highly successful treatment".

In 1995, DeGuzman *et al.* evaluated whether eleven American orthodontists would rate malocclusions the same as the PAR index. Two hundred models were rated for severity of the malocclusion and treatment. With use of the multiple regression and weighting from partial regression for the factors of the PAR index, the examiners were able to conclude that the evaluations made by the American orthodontists coincided with the PAR scores. The PAR index was an acceptable method to rate pre-treatment and post-treatment malocclusions for severity and can be used in analyzing the degree of success of orthodontic treatment.

In a study by Kerr and Buchanan (1993), 150 pre-treatment and post-treatment models of patients treated with removeable appliances were PAR scored. They found that there were flaws in the PAR index as a method for categorizing a case as "worse, no different, improved, or greatly improved" as did Richmond *et al.* (1992b). It was impossible for cases with pre-treatment scores below the score of

twenty-two to finish as "greatly improved" and it was inappropriate for cases with lower initial PAR scores to be considered less improved (Kerr and Buchanan 1993).

Additional Indices

In a comparison with other indices, like the Summers' Occlusal Index, the PAR index was found to be comparable for reliability and validity in analyzing the outcomes of orthodontic cases (Buchanan *et al.* 1993). In 1991, Shaw *et al.* discussed the uses of the IOTN (Index of treatment need) and the PAR index. They concluded that these indices were beneficial methods for outcome assessment and for comparison between different treatment modalities used to treat cases (Shaw *et al.* 1991). Use of indices could also be a factor for informed consent and identification of patients in need of treatment (Shaw *et al.* 1995).

Studies Utilizing the PAR Index for Studies on One Phase and Two Phase Treatment

Researchers have investigated the benefits of one phase treatment relative to two phase treatment. Although more studies are needed in this area, the following research gives an insight into the advantages of the two methodologies.

In 1995, Vig and Vig published research on the outcomes of two phases of treatment compared to one phase of treatment for five hundred class II division 1 patients 11-14 years. In this study the investigators used design analysis, which allowed for the consideration of tradeoffs between treatment options to be taken into consideration when comparing the treatment methods. Length of treatment, extractions needed, and outcome as measured by the PAR Index were accounted for

by the examiners. Scores were given to each of these factors and the overall scores computed for each patient. For example, nonextraction was weighted "0 points" and extraction was weighted "-50 points" to be added to the scores for PAR score and treatment length. The higher the score the more advantageous the treatment. The results showed that the most beneficial treatment for class II division 1 cases was one phase treatment. Although the examiners stated the need for further investigation in this area, they suggested that younger aged patients should be included in the future studies in order to represent those children that had growth modification therapy in the early mixed dentition (Vig and Vig 1995).

Also analyzing one phase and two phase treatment, Liveratos and Johnston (1995) retrospectively compared matched pairs of class II between the ages of 7 and 14 years that were nonextraction patients treated by a single practitioner. Discriminant analysis was used to determine cases that were similar enough to be used as matched pairs. Cephalograms, models, age, and gender were used to collect fifty-six variables to distinguish the "borderline" one phase and two phase patients. Initially, forty-one cephalometric values were measured including ANB, Y-axis, Wits, and nasolabial angle. Models were measured for arch width, arch length, space available, arch depth, and lower incisor crowding. Twenty-five two phase cases were treated with bionator appliances and edgewise braces and twenty-eight one phase cases treated with 0.022 slot edgewise braces. Because the one phase patients were approximately one year older, their cephalograms had to be enlarged 3% for comparison. The identical cephalometric and model measurements used for

the discriminant analysis were also used to compare the outcomes of the two groups. From the regional superimpositions, the changes of the maxillas and the mandibles were related to the position of the cranial bases and the position of the teeth were related to their basal bones. Movements in the direction of the class II correction were considered positive and those in the opposite direction negative. The total anterior-posterior changes were added for the patients. The investigators discovered that there was no significant difference in outcome between the two patient groups. Two phase treatment took eighteen months more and required an average of ten more appointments than the one phase treatment. Therefore, the examiners concluded that since the skeletal change was not significant, that one phase treatment was advisable treatment in mild or moderate class II patients (Liveratos and Johnston 1995).

In 1995, O'Brien *et al.* reported variables that affected the outcome of 250 class II, division 1 cases ages 11-14 years from the University of Pittsburgh. The study analyzed the affects of the number of treatment phases, the percentage of appointments kept, the number of repairs to appliances, the PAR index score and, whether patients were treated extraction or nonextraction. ANOVA determined that there was no significant difference between the pre-treatment PAR scores for the one and two phase patients and a significant difference between the extraction and nonextraction pre-treatment scores. Using multiple regression to test the effects of the variables, the examiners discovered that the pretreatment PAR index score was the only variable that affected the final PAR scores. Having two phases of treatment

did not affect the PAR index score significantly. This could have been a result of the fact that the study did not include patients younger than eleven years of age. If patients started treatment at younger ages, the early growth they experienced might have caused more significant differences between pre-treatment and post-treatment scores. Patients with higher initial PAR scores showed a greater improvement in their occlusion. The investigators discussed a possible bias for those patients with severe malocclusion who needed longer treatment times and had a higher probability of needing extractions. Therefore, several variables studied influenced each other and possibly the degree to which the PAR index score was influenced (O'Brien 1995).

Extraction Versus Nonextraction

Frequency

In 1979, Peck and Peck analyzed the extraction rate of Caucasian patients in the northeastern states. Only patients that had a full year of comprehensive orthodontic treatment, not including surgery patients or transfer patients, were studied. Of the 537 patients, 228 were males and 309 females with the age range from 7-14 years. The majority of the patients were between the ages of 10-12 years. To be counted as an extraction case, permanent teeth had to be extracted for the purpose of orthodontic treatment. No third molar extractions were considered. Peck and Peck discovered that, for their study, only 42.1% had extractions compared to a higher percentage of 83.5% previously recorded. Because extractions can be the method of choice for orthodontists when not receiving good compliance with

appliances such as headgears, the rate of extraction might be affected by the type of patients they treat and the treatment philosophy they follow.

In Michigan, telephone surveys were conducted to determine how 238 orthodontists estimated their extraction rates. This study was completed by Weintraub *et al.* in 1989. They discovered orthodontists were not accurate in estimating their own extraction rates. Those practices that were further investigated after the telephone survey revealed as high as a 20% discrepancy. The average rate was 39% with the range from 5-87%. Seventy percent of the patients had four bicuspids extracted. Of the 237 patients closely examined, an average of 3.5 teeth were extracted on each patient. Third molars were not included.

In 1993, O'Connor mailed surveys to fourteen hundred randomly selected members of the American Association of Orthodontists to compare results collected five years prior to those collected in 1993. Eight hundred and fourteen surveys were returned. For those orthodontists, the extraction rate had decreased from 37.7% to 29.3%. Twenty-six percent of the orthodontist had decreased the number of extractions they recommend due to the possible detrimental affects on the temporomandibular joint. Despite the findings by Sadowsky and BeGole thirteen years earlier, showing no causitive connection between the temporomandibular joint dysfunction (TMD) and extraction, orthodontists still hesitated to remove teeth on symptomatic TMD patients. In 1980, Sadowsky and BeGole surveyed 162 patients ages 25-55 years that had full fixed orthodontics in one of six Chicago practices 10-35 years earlier. They compared these patients to an untreated control group.

Seventy-five patients were in each group. The symptoms reported for the treated group had similar responses to the control group. Nonfunctional occlusal contacts were equally common in the treated and untreated samples and slides from initial retruded contact to intercuspation was slightly increased in the untreated sample.

Borderline Extraction Versus Nonextraction

At St. Louis University, thirty nonextraction and thirty-three extraction class II, division 1 cases were compared by Paquette *et al.* in 1992 after discriminant analysis identified them as "borderline" extraction and nonextraction cases. Initial lateral cephalograms, photographs magnified 21.5%, and initial models were measured for a total of thirty-seven variables. These variables allowed the investigators to eliminate all patients with definitive data in all of the records that categorized a patient as a definite extraction or nonextraction patient not "borderline". Those remaining "borderline" patients were recalled 10-20 years post-treatment for records. Studying the results revealed that the nonextraction patients had dental protrusion of 2 mm at the initial and recall visits. At recall, both the nonextraction and the extraction groups had less than 3.5 mm of lower anterior crowding. Relapse was found to be unrelated to the treatment rendered, but instead related to the growth of the jaws. The extraction patients had straighter profiles than the nonextraction patients, but still viewed their treatment successful (Paquette *et al.* 1992).

The Need for One Phase Versus Two Phase Studies

Although there are many valid arguments and biases that influence an orthodontist's decision whether to screen their patients for early and eventually two phases of treatment, evidence of improved treatment outcome might influence clinicians to follow certain methodologies. It would be beneficial to discover if orthodontists typically start patients early that have a certain severity of malocclusion, and not just because they have a particular type of malocclusion, for example a crossbite. Also beneficial would be the knowledge of how much improvement an orthodontist can expect with one versus two phases of treatment. The orthodontist should know whether the comprehensive phase or the second phase of two phase treatment should typically be initiated at a certain level of severity for a given malocclusion. Does early treatment get the case ready to start the comprehensive phase by correcting the malocclusion to a level of severity successfully treated by the second phase of treatment?

The PAR index is a reliable and consistant method for analyzing treatment. It can be used effective on early cases with primary teeth as well as cases with a full permanent dentition. By using the PAR index to measure models of cases treated with one phase and two phases of treatment, important questions not yet fully explored can be answered. Which method produces better outcomes and what is the amount of change in malocclusion a clinician can expect with either method? Can a clinician achieve the same results with either the methods? If not, at what severity

of malocclusion does a clinician typically begin each phase of treatment? Does two phase treatment decrease the extraction rate?

HYPOTHESES

The following are hypotheses to be tested:

1) Patients treated with two phases of treatment finish with lower PAR scores than those treated with only one phase of treatment.

2) The early treatment portion of two phase treatment reduces the PAR score to the initial level of one phase patients.

3) Those patients treated with early treatment have higher initial PAR scores than the one phase patients.

4) One phase treatment is similar in length and has the same percent reduction of the PAR scores as the second phase of two phase treatment.

MATERIALS AND METHODS

The study was an analytical, retrospective, longitudinal investigation of orthodontic patients that underwent one or two phases of treatment. Data was collected from a single provider in Norwalk, Ohio (Gary Wolf, D.D.S.,M.S.D.). The provider was selected based on the availability of pre-treatment an post-treatment records and the use of both two phase and single phase treatment options. Models of the completed cases, starting with the most recent, were selected to be scored. All the two phase cases were used and one phase cases physically closest to the two phase cases were chosen for the study.

Patient (Subject) Selection

Patients (subjects) included in the study had to meet the following criteria:

1) No syndrome patients with craniofacial anomalies

2) No surgical cases

3) No adults over the age of 18 years

4) All early treatment cases must have started treatment in the mixed dentition

5) All one phase cases must have treatment initiated in the permanent dentition

No subject was eliminated based on gender or race. An Institutional Review Board for Human Subjects (IRB) approval (see Appendix 4) was received to ensure

that the data extracted from the records was respectful of the patients. Patients of all differing Angle classes of malocclusion, treated with various combinations of functional appliances, were included in the study. In the final stage of treatment, all patients were treated with the 0.022 Roth prescription brackets manufactured by the A Company.

Scoring the Models

For each subject included in the study, the dental models were scored using the Peer Assessment Index (PAR) (Richmond 1994) by a single examiner (CSK). Calibration of the examiner in the PAR Index was completed in November 1997 by Dr. Roland Feghali. Three separate sets of models were scored for two phase patients: The initiation of the first phase of treatment (T0), the completion of first phase treatment/initiation of second phase of treatment (T1), and the completion of the second phase of treatment (T2). For one phase cases, two sets of models were scored; the initial models (T0) and completed models (T2). The PAR index includes scores for:

1) right buccal occlusion-vertical, transverse, A-P

2) left buccal occlusion-vertical, transverse, A-P

3) overbite/openbite

4) overjet/anterior crossbites

5) centerline

6) anterior displacement/impaction

The scores were tallied on a data sheet that appropriately weighs each variable of the index to give the total score (Appendix A). The PAR ruler was used to measure each section (Richmond 1994, as seen in Appendix B). Besides PAR data, other data collected for each patient included:

1) Patient gender

2) First phase initial date (for two phase patients only)

3) Dental age as determined by the remaining deciduous teeth (for two phase patients only)

4) Angle's molar classification for right and left buccal occlusion

5) Appliances used during the first phase of treatment (for two phase patients only)

6) Final first phase date (for two phase patients only)

7) Initial second phase date

8) Final second phase date

Information was collected from 551 patients. Two hundred one phase subjects and 201 two phase subjects were statistically analyzed and compared. One hundred and fifty were eliminated based on age and incomplete information.

Statistical Analyses

All statistical analyses were calculated using the Statistical Package for the Social Sciences (SPSS) for Windows® software (SPSS, Inc., Chicago, IL). Means and standard deviations were calculated for the continuous variables and chi-square was computed for categorical variables. Two sample t-tests assuming equal

variances were calculated for the PAR index scores between treated groups assuming alpha ≤ 0.05. The following comparisons were computed:

1) one phase T0 vs. two phase T0

2) one phase T0 vs. one phase T2

3) two phase T0 vs. two phase T1

4) two phase T0 vs. two phase T2

5) one phase T2 vs. two phase T2

6) one phase T0 vs. two phase T1

Percent reductions were calculated using the following equations:

$$R1=\frac{T0-T2 \times 100\%}{T0}$$

$$R2=\frac{T0-T1 \times 100\%}{T0}$$

T0=initial PAR score
T1=final early Tx PAR score
T2 = final PAR score
R1=total % reduction (T2-T0)
R2=% reduction(T1-T0)

Intraexaminer Reliabilty

Thirty subjects were randomly selected to be rescored four months after the original scoring with the PAR Index. Fifteen were one phase treated and fifteen two phase treated. Intraexaminer correlation coefficient was used to calculate the percent reliabilty at T0, T1, T2 to test the accuracy of the examiner in PAR scoring the models.

Intraexaminer correlation coefficient was calculated using the following equation:

$$R = \frac{MSb-MSw}{MSb+MSw}$$

R = Intraexaminer correlation coefficient
MSb = Mean square between subjects
MSw = Mean square within subjects

RESULTS

Demographics

The study has an analytical, retrospective design with a total sample of 401 (n=401); 200 one phase subjects and 201 two phase subjects. The PAR score showed a decrease from an initial 31.9 ± 8.6 to a final 4.2 ± 4.5 for the two phase subjects and 26.2 ± 9.2 to 3.8 ± 3.2 for the one phase subjects. Fifty-eight percent of the one phase subjects were female as compared to 55% female for two phase subjects. The average one phase subject started treatment at an older age than the two phase subject; 13 years and 9 years of age, respectively. See Table 1 for summary demographics.

TABLE 1.--Summary Demographics

Variables	**Single Phase**	**Two Phase**
Percentage female	58%	55%
Initial age	13.1 ± 2.0	9.9 ± 1.5
Initial dental age	Not applicable (NA)	8.8 ± 1.0

The one phase subjects were equal in number of class I and class II molar classifications on both the right and left sides. A majority of the one phase and two phase subjects had a class II molar classification on either the right or left side. Class I subjects were less numerous and class III was the least common in Table 2 and 3.

TABLE 2.--Total Number of Subjects with Class I, II, III Molar Classifications

Treatment Group	Class I R and L	Class II R or L	Class III R or L
One phase	81	113	6
Two phase	35	158	8

TABLE 3.--Total Number of Subjects with Subdivisions of the Class I, II, and III Molar Classification

Tx Group	Class I R&L	Class II R &L	Class III R&L	Class II Subdivi-sion R	Class II Subdivi -sion L	Class III Subdivi-sion R	Class III Subdivi-sion L	Class II R & Class III L
One phase	81	82	5	13	17	0	0	1
Two phase	35	136	6	18	4	1	1	0

Treatment Length

The average length of one phase treatment is shorter than the first phase of two phase treatment and equal in length to the second phase of two phase treatment. Two phase subjects started earlier and were in appliances 53% longer Table 4.

TABLE 4.--Treatment Length in Years

Treatment Group	First Phase (T0-T1)	Second Phase (T1-T2)	Total (T0-T2)
One phase	NA	NA	2.7 ± 0.5
Two phase	3.1 ± 1.5	2.6 ± 0.8	5.7 ± 1.7

Using the two-tailed t-test, assuming equal variance. the length of two second phase of two phase treatment (2.6 $\pm$ 0.8) was compared to the length of one phase treatment (2.7 $\pm$ 0.5). No significance was detected ($p = 0.22$). When comparing the total treatment length of one phase (2.7 $\pm$ 0.5) and two phase treatment (5.7 $\pm$ 1.7). the difference was significant ($p \leq 0.05$).

PAR Scores

Both the one phase and two phase subjects have high PAR scores indicating that subjects initiated treatment with more severe malocclusions. The two phase subjects have higher initial PAR scores than the one phase subjects. T1 scores for the two phase subjects are lower than the T0 scores for the one phase subjects. Both the one phase and two phase subjects finished with PAR scores below 5. See Table 5.

TABLE 5.--Average PAR Scores

Treatment Group	**Initial Score T0**	**Final T0/Initial Score T1**	**Final Score T2**
One phase	26.2 $\pm$ 9.2	NA	3.8 $\pm$ 3.2
Two phase	31.9 $\pm$ 8.6	21.9 $\pm$ 9.2	4.2 $\pm$ 4.5
Total pt mean	29.0 $\pm$ 9.3	NA	4.0 $\pm$ 3.9

Percent reduction shows the percent decrease in PAR scores for each treatment period. For the two phase subjects, the majority of the reduction occurs in the second phase of treatment Table 6.

TABLE 6.--Average Percent Reduction (% RED)

Treatment Group	%RED (T1-T0)	%RED (T2-T1)	Total %RED (T2-T0)
One phase	NA	NA	83.8 ± 16.1
Two phase	27.7 ± 32.6	58.0 ± 30.1	85.7 ± 16.5

One phase and two phase subjects were separated based on the molar classification, class I, II, and III. Individual PAR scores were averaged for these groups. One phase subjects with class I molar classification has the lowest initial PAR score (T0) and the lowest final PAR score (T2) see Table 7.

TABLE 7.--PAR Scores of the One Phase and Two Phase Subjects Separated by Molar Classifications

Treatment Group	Molar Classification	T0 PAR Score	T1 PAR Score	T2 PAR Score
One phase	I	22.8 ± 9.3	NA	3.7 ± 3.5
Two phase	I	26.6 ± 8.4	19.1 ± 9.2	4.1 ± 5.5
One phase	III	32.5 ± 11.3	NA	5.0 ± 2.8
Two phase	III	29.4 ± 9.0	27.6 ± 10.6	4.8 ± 3.7
One phase	II	28.4 ± 8.1	NA	3.9 ± 3.1
Two phase	II	33.1 ± 8.2	22.2 ± 9.1	4.2 ± 4.3

One phase and two phase subjects were separated into groups by molar classification, class I, II, and III. The percent reduction was calculated for the new groups. The largest total reduction was found in the two phase subjects with a class II molar relationship. The least reduction was found in the one phase class III subjects see Table 8.

TABLE 8.--Percent Reduction of the One Phase and Two Phase Subjects Separated by Molar Classifications

Treatment Group	Molar Classification	Total Percent Reduction	T1-T0 Percent Reduction	T2-T1 Percent Reduction
One phase	I	82.3 ± 19.3	NA	NA
Two phase	I	82.6 ± 24.1	22.0 ± 41.7	60.6 ± 35.0
One phase	II	85.2 ± 13.0	NA	NA
Two phase	II	86.5 ± 14.4	30.1 ± 30.0	56.4 ± 29.0
One phase	III	79.8 ± 19.5	NA	NA
Two phase	III	82.9 ± 13.8	4.8 ± 31.7	78.1 ± 24.4

Changes in PAR scores from T0 to T1 for those subjects treated with two phases of treatment were tested for significance using the t-test, assuming $p \leq 0.05$. Final scores (T2) were also compared for the molar classification groups between the one phase and two phase subjects. See Table 9.

TABLE 9.-- Significance Between T0 and T1 for Molar Classification Groups for Two Phase Subjects and Between One and Two Phase Subjects at T2

Molar Classification	Treatment Group	Actual Values	Significance at $P \leq 0.05$
Class I	two T0 vs two T1	26.6 ± 8.4 vs 19.1 ± 9.2	Yes
Class I	one T2 vs two T2	3.7 ± 3.5 vs 4.1 ± 5.5	No
Class II	two T0 vs two T1	33.1 ± 8.2 vs 22.2 ± 9.1	Yes
Class II	one T2 vs two T2	3.9 ± 3.1 vs 4.2 ± 4.3	No
Class III	two T0 vs two T1	29.4 ± 9.0 vs 27.6 ± 10.6	No
Class III	one T2 vs two T2	5.0 ± 2.8 vs 4.8 ± 3.7	No

Appliances

Multiple combinations of appliances were used during the early phase of two phase treatment. Most appliances are used partially to correct class II malocclusions. The facemask is the only appliance used exclusively for class III malocclusions. Other appliance combinations were possibly used by the clinician, yet not available with the measured models see Table 10.

TABLE 10.--Appliance Combination used in First Phase of Treatment

Appliance Combination	Class I	Class II	Class III
Frankel		5	1
Headgear (cervical, combination, high pull)		17	
Lingual holding arch, headgear, 2 by 4		1	
Frankel, bionator		2	
Palatal expander (bonded, Hilgers, hyrax)	10	44	4
Bionator	1	4	
Serial extraction	1	1	
Schwarz, TPA		1	
2 by 4	7	6	
Nance		1	
Headgear, 2 by 4	4	7	
Lingual holding arch, Schwarz		1	
Headgear, palatal expander	2	6	
Schwarz		2	
TPA, headgear		1	
Headgear, bite plate		2	
Lingual holding arch		4	
Bionator, palatal expander	1	2	

Table 10. continued on following page.

Table 10.--Appliance Combination used in First Phase Treatment (con't.)

Appliance Combination	Class I	Class II	Class III
Palatal expander, hg, 2 by 4		4	
Headgear, palatal expander, bionator		4	
Palatal expander, 2 by 4	1	2	
Frankel, palatal expander		1	
Palatal expander, facemask			3
Biteplate	2		
Frankel, palatal expander, 2 by 4		1	
Frankel, headgear	1	2	
Palatal expander. Biteplate, headgear		2	
Palatal expander, biteplate	2	1	1
Bionator, headgear		2	
Palatal expander, TPA, headgear		1	
Frankel, palatal expander, headgear		1	
Headgear, bionator, 2 by 4, biteplate		1	
Lingual holding arch, TPA, headgear		1	
Frankel, Schwarz, biteplate, headgear		1	
Palatal expander, TPA		1	
2 by 4, palatal expander, headgear, TPA	1		
Headgear, bionator, 2 by 4		1	
Biteplate, headgear, TPA		1	
TPA		1	
2 by 4, biteplate		3	
Lingual holding arch, palatal expander		1	
Lingual holding arch, headgear		1	
Biteplate		1	
Lingual holding arch, bionator		1	
Schwarz, palatal expander		1	
Schwarz, bionator		1	

Palatal expanders including the cervical, combination, and high pull varieties are most popular type of appliance used by the clinician during the early phase of

two phase treatment. They are used for all there classification groups (I, II, III) (Table 11).

TABLE 11.--Total Number of Appliances used During Early Treatment

Appliances	Number
Bionators	19
Palatal expanders	97
Frankels	15
Headgear	65
2 by 4	39
Biteplate	14
TPA	7
Lingual holding arch	9
Serial extraction	2
Schwarz	7
Nance	1

PAR scores and percent reduction for two phase subjects treated with palatal expanders were similar to the average scores for all two phase subjects. See Table 12.

TABLE 12.--Palatal Expansion Subjects Compared to Averages for Two Phase Subjects

Variables	Palatal Expansion Subjects	Two phase Subjects
Percent reduction	86.1% $\pm$ 14.9	85.7% $\pm$ 16.5
PAR score T0	31.9 $\pm$ 8.4	31.9 $\pm$ 8.6
PAR score T1	22.7 $\pm$ 9.0	21.9 $\pm$ 9.2
PAR score T2	4.2 $\pm$ 4.2	4.2 $\pm$ 4.5

PAR Score Comparison Between One Phase and Two Phase Treatment

The mean PAR score for the two hundred one phase subjects is 26.2 ± 9.2. The one phase subjects were sequentially listed from highest initial PAR score to the lowest. The lowest scores were eliminated until the mean for the remaining one phase subjects equaled 31.9, the same severity of dental malocclusion as initial two phase subjects. The final PAR score for the remaining one phase subjects was compared to the final PAR score for the two phase subjects (Table 13).

TABLE 13.--Mean PAR Score for Remaining One Phase Subjects Compared to Two Phase Subjects

Treatment Group	Initial (T0)	Final (T2)
One phase	31.9 ± 6.6	4.1 ± 3.1
Two phase	31.9 ± 8.6	4.2 ± 4.5

Extraction vs. Non-extraction

One hundred one phase subjects and one two phase subjects were randomly selected from the original sample. The number of extraction cases were counted for each group (see Table 14 and 15). The difference in extraction percentage between the one and two phase groups were statistically significant with $p \leq 0.05$.

TABLE 14.--Number of Extractions for Each Group

Treatment Group	Number Extraction	Number Non-extraction	Extraction Percentage
One phase (n=100)	42	58	42%
Two phase (n=100)	30	70	30%

Majority of the extractions were of the upper and lower first bicuspids in one phase subjects (Table 15).

TABLE 15.--Teeth Extracted in One Phase and Two Phase Subjects

Treatment Group	Four First Bicuspids	Four Second Bicuspids	Two Maxillary First Bicuspids	Lower Single Anterior
One phase	38	4	7	0
Two phase	23	5	4	0

The two hundred subjects were divided into molar classification groups. The extraction rates were calculated for each group. See Table 16.

TABLE 16.--Extraction Percentages for Molar Classification Groups

Molar Classification Group	Extraction Percentage
Class I	35.4%
Class II	34.7 %
Class III	62.5%

Of the one hundred two phase subjects counted for the extraction rate, palatal expansion subjects were the most common and had an extraction percentage of 16.5%.

Tests For Significance

The significance of the difference between the initial (T0), initial/final (T1), and final (T2) PAR scores was assessed using the two-tailed t-test, assuming equal variances, for one phase and two phase treatment assuming alpha = 0 .05 (Table 17).

TABLE 17.--Significance in the Change in PAR Scores within One Phase and Two Phase Treatment Groups

Treatment Group	**Scores Compared**	**Actual Scores**	**Significance at $P \leq 0.05$**
One phase	T0 vs T2	26.2 vs 3.8	Yes
Two phase	T0 vs T1	31.9 vs 21.9	Yes
Two phase	T1 vs T2	21.9 vs 4.2	Yes
Two phase	T0 vs T2	31.9 vs 4.2	Yes

With the use of the two-tailed t-test, assuming equal variance, the PAR scores at T0,T1, and T2 were compared for significant differences between one phase and two phase treatment groups, alpha = 0.05 in Table 18.

TABLE 18.--Significance Between One Phase and Two Phase PAR Scores at the Three Stages in Treatment

Treatment Group and Stage of Treatment	**Actual Values**	**Significance at $P \leq 0.05$**
One T2 vs two T2	3.8 ± 3.2 vs 4.2 ± 4.5	No
One T0 vs two T0	26.2 ± 9.2 vs 31.9 ± 8.6	Yes
One T0 vs two T1	26.2 ± 9.2 vs 21.9 ± 9.2	Yes

The amount of percent reduction in PAR scores are compared between the one phase and two phase treatment groups using two-tailed t-test, assuming equal variance in Table 19.

TABLE 19.--Percent Reduction in Treatment Stages as Compared Between One and Two Phase Treatment

Treatment group and Stage of Treatment	**Percent Reduction**	**Significance at $P \leq 0.05$**
One total vs two total	83.8 + 16.1 vs 85.7 $\pm$ 16.5	No
One total vs two T1-T2	83.8 $\pm$ 16.1 vs 58.0 $\pm$ 30.1	Yes

Percent Reliabilty

Percent reliability tests the examiners accuracy in rescoring randomly selected models from both the one phase and two phase treatment groups. The reliability is calculated using the intraexaminer correlation coefficient. The initial T0 scores versus the rescored T0 models resulted in r = 0 .99. T1 initial versus T1 rescored is r = 0.99. T2 initial versus T2 rescored is r = 0.94. The r values indicate excellent intraexaminer reliability.

DISCUSSION

When orthodontists start cases, they aim for the best possible result. The design of the treatment plans, the projected length of the treatment, and the timing of the onset of treatment are estimated and reported to the parents before treatment begins. The purpose of this study is to determine what are the results that can be expected using one phase and two phase treatment using the PAR index. The dental and chronological age at initial treatment, the length of each phase of treatment, and the decrease in PAR score with one phase and two phase treatment were assessed. The percent reduction of the PAR scores with treatment and the extraction percentages were also recorded.

Standards for Successful Treatment

For the present study, the initial PAR score for the one phase patients was 26.2 and the score for the two phase patients was 31.9. These scores were lower than the scores recorded by Fox in 1993 (32.4). Because the practitioner had strict criteria for selecting patients for two phase treatment, the two phase patients had significantly higher initial PAR scores than the one phase. By selecting patients treated throughout the career of the subject orthodontist, there was an effort to eliminate those patients that were treated with one phase of treatment because they were initially seen at older ages, missing the chance for early treatment. The

orthodontist had a referral base that recommended younger children for early treatment, allowing the orthodontist to decide to recall the patients until the onset of one phase treatment or initiate the early phase of two phase treatment.

Both scores were reduced to below 5 with treatment, 3.8 for the one phase patients and 4.2 for the two phase patients. Individual scores were recorded as low as zero. Although these scores seem low, Tulloch *et al.* in a progress report in 1998 also reported patients with final scores of zero. They reported that a nearly perfect PAR score is below five. Richmond *et al.* (1992) indicated high quality treatment as an average percent reduction of seventy percent. The low final PAR scores for both the one phase and two phase patients can be explained by the competence of the practitioner in successfully treating patients in either phase. Future studies including many practitioners may better demonstrate the norm for treating patients in either phase. The mean total percent reduction was equally as impressive for the two groups, 83.8% for the one phase patients and 85.7% for the two phase patients. With the use of both Proffit's and Richmond's standards, the results indicate excellent quality treatment.

The two phase patients had an additional PAR score (T1) taken of the model after phase one treatment and prior to the second phase of treatment. The mean score of 21.9 indicated a 10 point reduction in PAR score during the first phase or a 27.7% reduction. The majority of the malocclusion correction was achieved during the second phase of two phase treatment. It is possible that skeletal and facial changes were the concentration during the first phase and the minor dental improvements an

additional benefit of the skeletal changes. The remaining dental correction was the goal of the second phase and was comparable to the one phase group. The first phase of two phase treatment reduced the original score below the initial mean score of the one phase patients. The second phase of two phase treatment needed to correct less malocclusion to achieve the same final result as one phase treatment.

Treatment Length

The total treatment time for one phase treatment was 2.7 years. The average total for two phase treatment was 5.7 years. The two phase treatment took 53% longer. The first phase of two phase treatment took 3.1 years and the second phase took 2.6 years. No significant difference was discovered between the total length of one phase treatment and the second phase of two phase treatment. The additional time of 3.1 years was used in two phase treatment to reduce the PAR score of 31.9 to 21.9, only 4.3 points below the initial 26.2 for the one phase patients. One factor not included in the consideration of the length of two phase treatment was the recall visits. Both the one phase and the two phase patients had records taken at the onset of the treatment. During the first phase of two phase treatment, many times the patients wore appliances as forms of retention and were placed on recall until the second phase records were taken to initiate the final phase of treatment. There was no direct method to determine the length of recall. Therefore, the active treatment in the two phase groups was occasionally much less than the average 5.7 years.

Age at the Initiation of Treatment

Another factor in treating two phase patients as opposed to one phase patients is the initial chronological and dental ages. Those patients treated in two phases of treated began treatment at the mean age of 9.9 years, while those treated in one phase began at the mean age of 13.1 years. Different motivational and explanatory mechanisms are needed for younger patients. Although younger patients can be more obedient to their parents and less influenced by the social stigma of wearing braces, the length of treatment can lead to "burnout" and even less compliance during the teenage years in the second phase of two phase treatment. Because chronological age frequently does not coincide with dental eruption, the mean dental age was calculated for the two phase patients using the erupted permanent teeth as a guide. The mean age was 8.8 years, slightly less than the mean chronological age. In cases where the dental age is significantly less than the chronological age, the patient may have been placed in recall for a longer period of time, increasing the overall time in treatment.

One Phase and Two Phase Patients with the Same Severity of Dental Malocclusion

The initial PAR scores for the one phase patients were organized from greatest to least and the lesser PAR scores were eliminated until the remaining scores had a mean of 31.9. This was comparable to the mean initial PAR score for the two phase patients (31.9). The mean final PAR score for the remaining one phase patients was calculated to be 4.1. This score was similar to the final two phase score of 4.2.

The same severity of dental malocclusion was treated in one phase in less time with the same result. These results disprove the theory that more severe dental malocclusions take more time to complete and should be started at younger ages.

PAR Score Differences Between Class I, II, III Molar classifications

Of the 401 patients included in the study, the majority had a class II molar relationship on either the right or left side. The two phase group had the most class II patients. Class I patients were the second most common and class III patients were the least common. These findings match what was found by Proffit in 1993. The class II patients had higher initial PAR scores compared to the overall means for the two phase groups. The percent reductions were also higher for the class II patients in both groups, 85% for one phase and 87% for two phase. Because overjet is weighted heavily in the PAR index, the initial scores for class II patients would be higher and even a mild decrease in overjet would significantly decrease the score. Although class II patients had higher initial PAR scores, the final scores for both groups were similar to the overall averages, 3.9 for one phase and 4.2 for two phase. The orthodontist treated patients to the same level of malocclusion despite initial class II molar classification. The practitioner is consistent in his criteria for debanding the patients. Class III patients treated in one phase had higher initial PAR scores than those chosen for two phase treatment. It is possible that the class III patients treated with two phases started treatment before much growth of the mandible causing the more severe dental malocclusions. The class I patients had lower initial PAR scores than the overall average and lower final PAR scores. Since less correction is needed in the

anterior-posterior direction for class I patients, these patients are the easier patients to treat. In the study sample, the class II patients started treatment with the most severe dental malocclusions; however, the class III patients finished with the highest PAR scores. The class I patients seemed to be the easiest to treat having the lowest initial and final PAR scores.

Demographics

More females than males comprised both the one and two phase treatment groups. This may be due to greater esthetic concern of females or the proportion of females in the population of Norwalk, Ohio during the treatment years included in the study.

Appliances

Several different combinations of appliances were recorded for the two phase patients. The appliances used were stored in the model boxes and were recorded during the PAR scoring. Misplacement of appliances or discarding of mutilated appliances may lead to incomplete appliance combinations recorded for patients. Of the appliances recorded, most appliance were used to treat class II molar classifications. The only appliance used for exclusively class III molar classifications was the facemask. Combinations of headgear, either high-pull, combination, or cervical, and palatal expanders were common as well as 2 by 4 bracket placement. These frequencies of appliance usage seem reasonable for two phase patients treated in a private office.

Extraction versus Nonextraction

Because the study has discovered that the same PAR scores can be achieved whether the patients are treated with one or two phases of treatment and that additional treatment time not necessarily means better results, it was important to determine if two phase treatment eliminated the need for extractions. Of two hundred patients randomly selected, the one phase patients had more extractions with 42% and the two phase patients had 30% extraction. The two phase patients had a significant decrease in the extraction rate when compared to the one phase patients. The palatal expansion patients had the lowest extraction rate of 16.5%. The increase in arch width may have eliminated the crowding ordinarily corrected with extractions. When comparing these rates to Tulloch *et al.* (1998) of 17% for their control group and O'Connor (1993) of 29.3%, the percentages for this study seem high. The majority of the extractions were of the four first bicuspids. It is possible that because the practice used for this study is in a rural area and not in direct competition with neighboring practices, that the orthodontist was able to extract teeth when deemed necessary without influence form the trend of other orthodontists. By including all the patients treated by the practice, the extraction rate may decrease further.

Difficulties with the PAR Index

Despite the ease of the PAR index for assessing malocclusions, there are many variables that effect the dental condition that are not included in the index. The index weights heavily the overjet, overbite, and anterior displacement. Factors such as lower anterior crowding and gingival health are not considered. Treatment including

the extraction of a single lower incisor can detrimentally effect the midline score for those patients because the examiner has to estimate the approximate location before extraction. Many orthodontists finish cases with the upper second molars out of occlusion to allow them to "settle". These cases have higher scores for the right and left buccal segments of the PAR scores. Patients treated nonextraction that finish with severe bimaxillary protrusion are not penalized with an increase in PAR score. Gingival contour and overall gingival health is not included in the index. The PAR index is simple to use to assess the permanent dentition. Its use can be questionable for use with mixed dentition cases. The index does not account for posterior occlusion in the mixed dentition. For example, flush terminal plane is considered normal posterior occlusion for the primary dentition; however, mixed dentition cases that have not exfoliated the primary molars may have a class II molar classification of the permanent molars until the primary molars have exfoliated and the permanent molars have drifted mesially into a class I molar. The temporary class II stage in the mixed dentition leads to higher PAR scores for the right and left buccal occlusions. If used consistently by the investigator, the PAR score should be a valuable measuring device to be used with the mixed dentition cases.

Possible Reasons to Recommend Two Phase Treatment

Treating patients with two phase treatment requires more appointments and chair time. Frequently, lab fees are high for the appliances used in early treatment and more time is needed to explain and assist parents in the activation of the appliances. Many orthodontists charge separate fees for the first phase and second phase of

treatment. It can be argued that an orthodontist might support two phase treatment in order to collect higher fees from the patients. However, according to this study, avoiding extractions is the key reason for treating a patient in two phases. An orthodontist can achieve the same dental result while saving the patient time and money if extractions are not a concern.

One factor that can explain the small decrease in PAR score during the first phase of two phase treatment might be a lack of cooperation by the patients and their parents. Although parents are generally concerned about the esthetics of their child, their desire to actively participate in treatment can be lacking. This is possibly the cause for the minor difference found by the study between the one phase and two phase patients. In ideal circumstances, two phase treatment may overwhelming result in lower PAR scores.

The study indicates that, practically speaking, one phase treatment is most beneficial for the correction of dental malocclusions. An immeasurable advantage of two phase treatment is a possible psychological benefit to children and parents by an improved appearance of the teeth at an earlier age. Early alignment or correction of severe protrusion may aid in self confidence and improve social interaction.

It was equally possible to correct a dental malocclusion with either one phase or two phase treatment as shown previously by the insignificant differences in the total percent reductions and final PAR scores. This does not eliminate the possibility that two phase treatment may make a significant difference in skeletal and facial changes when compared to the one phase patients. Cephalometric analyses and studies

comparing the initial and final facial profiles in the photos of the same study sample may be able to relate the degree of dental correction with the amount of facial and skeletal change. Further study is needed in this area before it can be conclusively determined that the only reason an orthodontist should recommend two phase treatment is to avoid extractions.

SUMMARY AND CONCLUSIONS

The treatment outcomes of one and two phase treatments groups were compared using the PAR index. Two hundred one phase subjects and 201 two phase subjects were randomly selected from the private practice of Dr. Gary Wolf in Norwalk, Ohio. Two sets of models were scored for the one phase subjects, the initial models (T0) and the final models (T2). Three sets of models were scored for each two phase subject, the initial (T0), the initial for the second phase (T1), and the final set (T2). Other variables examined include the subjects' chronological and dental ages, treatment length, percent reduction during each phase of treatment, appliance used, and the extraction rate.

The study revealed the following results:

1) The average two phase subject initiates treatment at a younger age relative to the one phase subjects (9.9 $\pm$ 1.5 years vs. 13.2 $\pm$ 2. years).

2) The average two phase subject initiates treatment with a more severe dental malocclusion than the one phase subjects (one phase initial PAR score = 26.2 $\pm$ 9.2, two phase initial PAR score = 31.9 $\pm$ 8.6).

3) Subjects with Class II molar relationships treated in two phases of treatment had the highest initial PAR scores (mean of 33.1 $\pm$ 8.2). final PAR scores (mean of 3.7 $\pm$ 3.5).

4) One phase and two phase subjects completed treatment with the same degree of malocclusion (one phase final PAR score = 3.8 $\pm$ 3.2, two phase final PAR score = 4.2 $\pm$ 4.5).

5) One phase subjects that initiated treatment with the same mean PAR scores as the two phase subjects had an identical final PAR score as the two phase subjects. The same severity of dental malocclusion was treated in one phase with the same result.

6) The first phase of two phase treatment reduced the degree of malocclusion below the initial degree of malocclusion for the one phase subjects.

7) The overall treatment length was increased by three years with two phase treatment.

8) The majority of the subjects treated with either the one or two phases had Class II molar relationships.

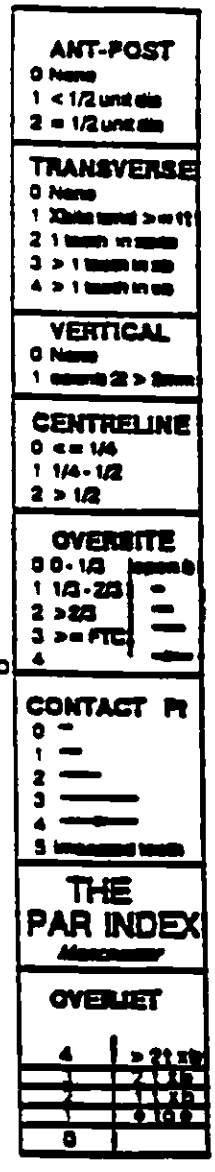
9) The common appliances used in the first phase of two phase treatment were headgears (cervical, combination, and high pull) and palatal expanders and 2 by 4 bracket placement. Facemasks were used to treat Class III molar relationships exclusively.

10) The total percent reduction of the PAR scores was statistically the same for both the one phase and two phase subjects (83.9 % + 16.1 vs. 85.7% + 16.5). The majority of the reduction occurred in the second phase of two phase treatment.

11) The extraction rate was lower for the two phase subjects as compared to the one phase subjects. The four first bicuspids were the most commonly extracted teeth.

It can be concluded that an orthodontists is able to correct severe dental malocclusion with one phase treatment, finishing to the same degree of occlusion as if treated in two phases. In addition, treatment length is minimized with one phase treatment. Two phase treatment would be advisable to decrease the need for extractions.

APPENDIX 1. 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 antero- crossbite ratings. These ratings are summed if both are present.

APPENDIX 2. PAR scoring sheet

PAR INDEX COMPONENT	SUB-COMPONENTS	RAW PAR SCORE	WEIGHTING (Cleveland)	WEIGHTED PAR SCORE
Maxillary Anterior Alignment	Displacement			
	Impaction			
	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			
	Impaction			
	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. Raw data

TABLE 20. – Data for one phase and two phase patients

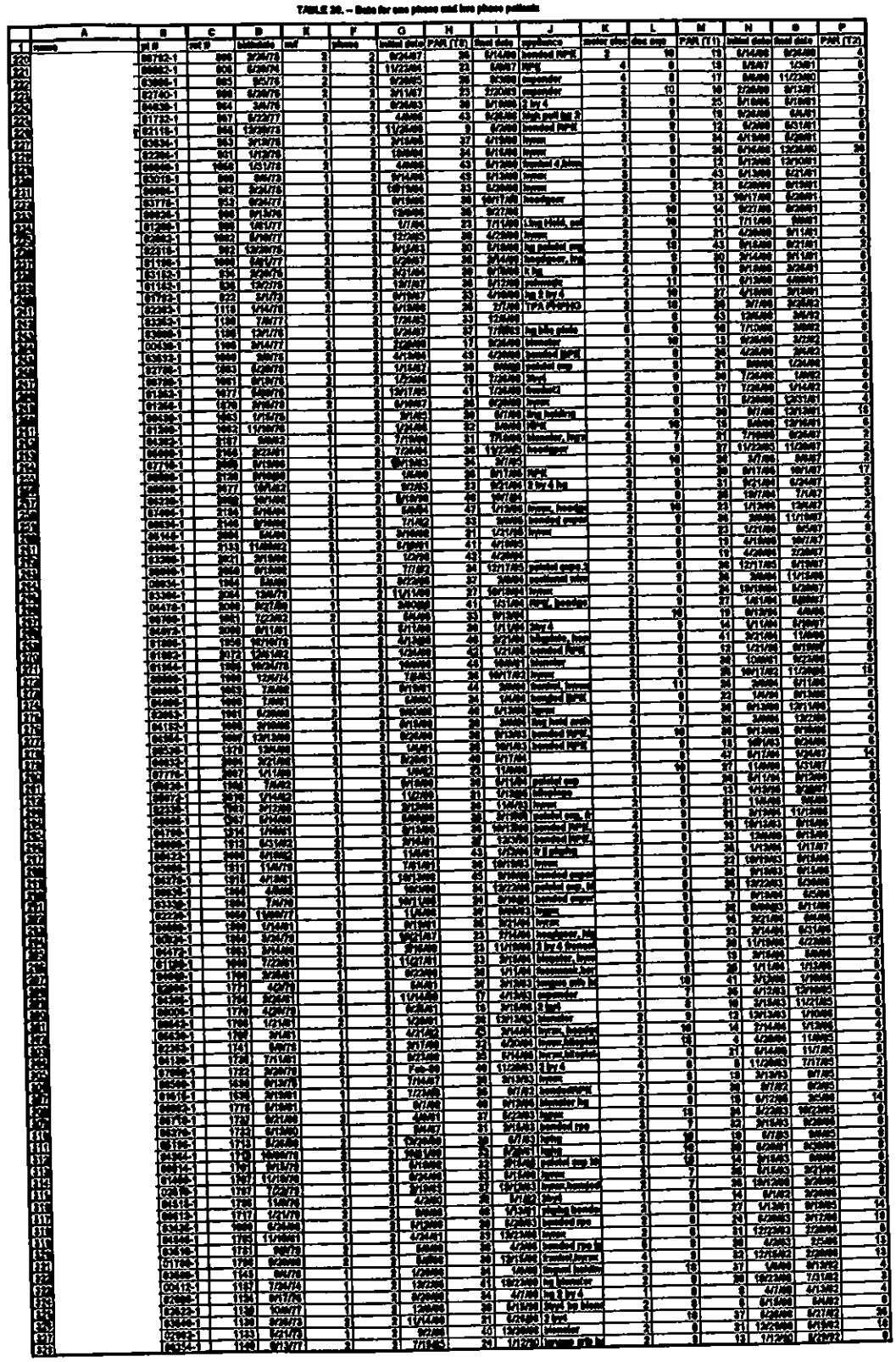
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	name	pt #	ref #	birthdate	ref	phase	initial date	PAR (T1)	final date	appliance	molar class	doc age	PAR (T1)	initial date	final date	PAR (T2)
2		02446-1	261	6/6/73	1	1	4/1988	14			3				4/1987	8
3		06358-1	308	3/1/1963	2	1	12/1984	21			4				4/27/87	8
4		01196-1	272	9/6/73	2	1	8/14/84	43			2				6/8/87	8
5		06620-1	301	6/26/73	2	1	4/2/86	39			1				8/24/87	6
6		01304-1	311	7/28/70	1	1	7/1/84	26			6				8/4/87	6
7		01748-1	317	6/1/1976	2	1	11/28/86	26			4				8/17/87	2
8		02952-1	362	6/1/1967	2	1	7/1/1984	43			2				9/1/1987	6
9		06182-1	326	11/8/1979	1	1	4/1988	22			5				10/1/1987	4
10		02398-1	367	1/1/1975	2	1	9/1988	19			1				10/1/1988	4
11		01474-1	341	4/23/1974	1	1	8/2/1985	8			1				1/8/1987	1
12		01888-1	346	3/24/74	1	1	4/1/1986	13			5				12/14/1987	2
13		01838-1	361	7/1/1973	2	1	6/1/1985	33			2				10/23/1987	6
14		06536-1	361	9/15/76	2	1	8/2/1988	39			4				11/1/1987	6
15		04994-1	366	11/28/79	1	1	8/2/1988	43			4				12/1987	6
16		06334-1	372	11/30/71	2	1	7/24/1988	34			2				11/1/1987	2
17		06280-1	363	12/1/1963	1	1	10/1/1988	39			1				1/1/1988	2
18		06866-1	386	6/1/1971	2	1	1/2/1988	39			1				1/1/1988	4
19		06864-1	381	1/4/76	2	1	9/2/1988	39			1				12/1/1988	6
20		01822-1	401	1/13/71	1	1	10/1/1988	36			5				6/1988	4
21		06864-1	406	7/22/73	1	1	7/1/85	33			2				9/1/1988	2
22		06760-1	411	7/8/73	2	1	1/2/1988	36			2				2/1988	6
23		06156-1	437	9/1/1971	1	1	8/8/85	37			2				5/1/1988	6
24		03198-1	446	8/1/1971	2	1	8/2/1988	17			1				6/1988	6
25		05864-1	436	8/24/71	2	1	10/1/1988	14			1				6/2/1988	2
26		03306-1	461	1/1/1973	2	1	8/1/1988	23			2				6/1988	2
27		03663-1	466	1/31/75	2	1	7/1988	31			2				7/1/1988	3
28		01372-1	478	10/11/72	2	1	11/2/1988	36			2				7/2/1988	4
29		06866-1	486	3/18/72	2	1	4/2/1988	13			4				8/1988	6
30		06536-1	493	4/28/72	1	1	3/24/1988	39			2				8/1988	2
31		06864-1	497	10/29/73	2	1	8/1/1988	13			2				8/2/1988	6
32		01348-1	501	9/1/1967	1	1	12/27/1988	36			1				8/2/1988	6
33		06288-1	506	3/6/73	2	1	10/1/1988	31			2				7/1988	6
34		06866-1	511	12/9/72	2	1	8/27/1988	39			4				9/1988	6
35		06866-1	516	7/6/72	1	1	4/1/1985	39			2				10/1/1988	13
36		06536-1	521	12/6/63	2	1	8/2/1988	34			1				9/1/1988	6
37		01344-1	527	5/24/68	2	1	9/8/88	11			1				11/1/88	6
38		06866-1	541	12/2/63	2	1	7/1/88	36			6				12/1988	2
39		01466-1	571	4/28/74	1	1	11/4/87	16			1				8/2/1961	17
40		02384-1	581	11/1/1963	2	1	7/1/1988	31			5				12/1/1988	4
41		01512-1	586	12/28/72	1	1	6/2/1988	36			2				1/1988	6
42		06166-1	591	9/1/1973	2	1	10/2/1988	34			4				3/1988	3
43		06762-1	601	6/27/66	2	1	1/1/1987	17			6				9/17/88	6
44		02478-1	616	1/3/73	2	1	4/8/87	13			1				4/2/88	6
45		06866-1	621	8/19/74	2	1	12/1/1988	34			2				4/1/1988	4
46		07866-1	636	8/2/1966	2	1	7/1988	19			6				8/1/1988	2
47		06762-1	636	11/23/73	1	1	10/2/1988	21			6				8/22/88	1
48		01978-1	646	6/18/74	2	1	4/8/87	36			2				8/22/88	1
49		02434-1	667	1/19/73	2	1	8/4/87	17			4				8/1/1988	4
50		01868-1	671	2/1/73	2	1	6/1/1987	33			2				9/1/1988	3
51		02774-1	676	12/6/76	2	1	12/1/1988	33			2				10/1988	7
52		06870-1	681	10/8/74	2	1	12/2/1988	43			2				7/24/88	7
53		06762-1	686	1/1/1980	1	1	8/2/1988	23			2				2/2/1988	3
54		01536-1	692	7/3/73	2	1	6/1/1987	37			2				10/1988	3
55		06866-1	696	12/9/73	2	1	4/2/1987	32			1				8/2/88	10
56		02766-1	706	6/27/72	1	1	11/2/1987	36			2				9/2/1988	10
57		01766-1	712	7/19/76	2	1	8/2/1987	34			2				12/1988	2
58		02616-1	716	4/13/76	2	1	12/1988	39			1				10/1988	8
59		03366-1	741	7/19/76	2	1	11/1987	39			1				1/2/1988	4
60		03866-1	746	12/19/76	2	1	10/1/1987	16			1				8/1988	4
61		03514-1	761	6/7/76	2	1	6/1988	36			3				8/1988	10
62		06614-1	761	9/24/76	2	1	8/1987	21			3				3/27/88	3
63		06136-1	771	3/28/76	2	1	8/1987	39			2				4/1/1988	2
64		03116-1	776	8/8/76	2	1	8/2/1988	13			6				4/1/1988	4
65		06870-1	786	12/28/76	1	1	12/1/1988	36			1				7/27/88	6
66		02616-1	791	8/14/76	2	1	8/1/1987	13			1				8/2/1988	2
67		01866-1	796	1/8/76	1	1	8/2/1987	36			4				8/2/1988	4
68		01484-1	801	11/2/1976	1	1	8/2/1987	16			2				8/27/88	10
69		01736-1	811	9/11/76	2	1	4/1988	33			3				8/2/1988	6
70		02466-1	816	8/24/76	1	1	7/1/1987	47			2				7/14/1988	2
71		02184-1	821	8/2/1974	2	1	8/2/1988	34			1				7/27/1988	6
72		06513-1	826	8/7/76	1	1	8/2/1988	36			1				1/17/87	11
73		06733-1	836	3/27/76	2	1	8/1/1988	11			4				8/2/1988	6
74		02366-1	843	8/2/71	1	1	8/2/1988	36			2				8/27/1988	2
75			846	12/8/76	1	1	8/2/1988	36			2				8/1/1988	4
76		02886-1	861	1/8/74	2	1	12/1/1988	36			2				8/21/1988	2
77		06866-1	871	3/8/76	2	1	9/1/1987	17			1				11/8/88	10
78		01513-1	876	8/24/71	2	1	9/1/1987	34			2				11/1/1988	6
79		06762-1	2153	8/1/1982	1	1	8/1988	19		2					10/8/87	2
80		06516-1	2167	6/4/82	1	1	8/2/1988	13			1				11/24/87	2
81		06134-1	2127	12/14/75	1	1	8/7/88	14			2				10/1/87	6
82		06866-1	2068	8/1/61	1	1	2/1988	39			2				8/4/87	6
83		06872-1	2071	8/1/1988	2	1	1/4/88	27			1				8/17/87	4
84		06166-1	2084	8/2/63	2	1	4/28/88	22			1				7/2/87	2
85		06314-1	2163	12/2/1988	2	1	8/1/1988	37			3				12/8/87	6
86		07732-1	2147	8/8/62	1	1	8/27/85	36			2				11/1/87	3
87		06866-1	2166	8/1/61	1	1	8/7/88	40			3				12/4/87	6
88		06866-1	2072	8/1/61	2	1	11/1/1988	37			2				8/2/87	4
89		04388-1	2061	10/17/88	2	1	7/2/1983	39			2				7/1/87	6
90		07834-1	2023	7/2/61	2	1	8/1/1988	21			2				8/7/87	10
91		06736-1	2013	8/1/1963	2	1	2/1984	36			3				10/2/87	2
92		07866-1	2053	12/2/1988	2	1	1/2/1988	31			1				8/1/87	6
93		06766-1	2063	11/4/88	2	1	8/1/1988	33			3				8/1/87	3
94		06762-1	2061	12/2/1977	2	1	11/1/1988	33			1				8/1/87	7
95		06872-1	2053	2/1984	2	1	1/1988	36			3				8/4/87	4
96		06536-2	2061	1/8/1961	2	1	11/1/1988	36			3				8/2/87	6
97		04372-1	2068	1/8/63	2	1	1/2/1988	34			3				8/21/87	2
98		02466-1	1941	11/21/61	2	1	8/2/1988	22			3				10/1/1988	1
99		04388-1	2053	10/1/1988	1	1	8/2/1984	17			1				8/1/1987	7
100		05866-1	1940	7/26/61	1	1	7/1/1988	17			1				11/1/1988	6
101		06316-1	1927	1/1/1963	2	1	7/1/1988	14			1				9/1/1988	12
102		06464-1	1970	3/1/73	1	1	8/17/1988	44			2				12/1988	6
103		06866-1	1988	7/8/73	2	1	8/21/1988	36			1				8/1/1988	4
104		06536-1	1949	11/7/61	2	1	8/8/1988	36			2				11/1987	4
105		06536-1	1918	8/2/1988	2	1	8/1/1988	19			1				8/1/1988	6
106		06536-1	1962	3/14/72	1	1	4/2/1988	36			1				12/1/1988	8
107		06866-1	1967	8/24/62	2	1	11/1/1988	14			1				8/1/1987	8
108		01864-1	1988	7/24/78	1	1	1/31/95	39			6				8/2/1988	4
109		06536-1	2000	7/1/62	1	1	8/1/1984	19				1			2/1987	2
110		07866-1	1938	8/1/1962	2	1	8/8/84	22			2				8/1/88	2

APPENDIX 3. Raw data

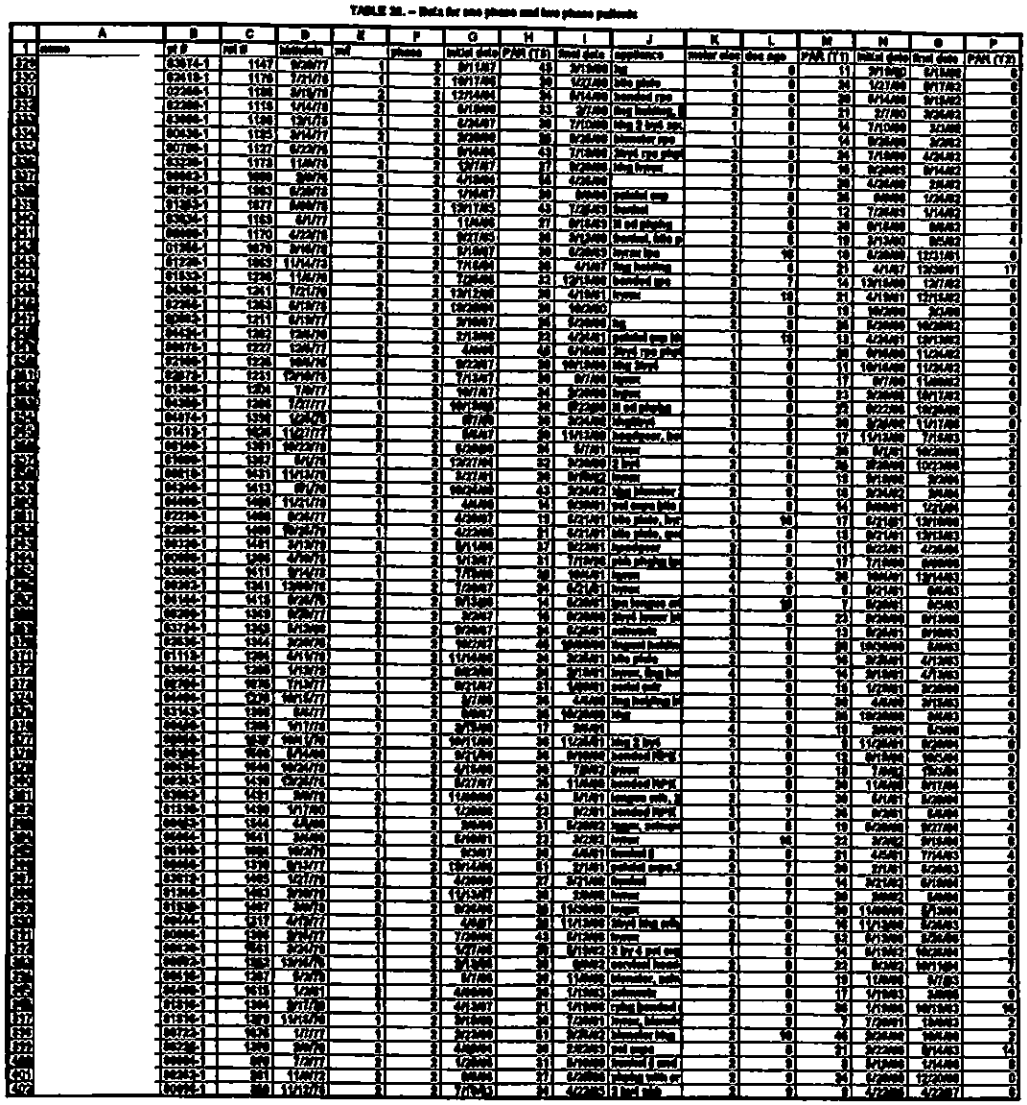
TABLE 30. – Data for one phase and two phase patients

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	name	pt #	ref #	birthdate	ref	phase	initial date	P/R (T1)	final date	appliance	molar class	gen. age	P/R (T1)	initial date	final date	P/R (T2)
111		67949-1	3420	9/27/66	1	1	6/3/94	34			1				3/24/97	2
112		06126-1	1964	10/27/66	2	1	9/17/94	23			1				11/4/96	2
113		67515-1	1913	6/6/61	1	1	3/2/94	36			2				9/15/98	6
114		04124-1	1913	6/6/6666	1	1	7/8/93	33			1				9/14/98	4
115		67778-1	2005	7/22/66	2	1	11/2/93	37			2				1/24/97	0
116		06562-1	1966	11/6/66	1	1	4/4/93	30			6				9/7/96	6
117		67134-1	1917	3/6/61	1	1	4/12/92	18			1				9/15/98	2
118		67515-1	1922	6/2/75	2	1	9/6/93	13			1				4/5/96	6
119		06290-1	1966	7/19/76	2	1	9/1/94	9			1				4/28/98	6
120		67966-1	1927	6/26/61	2	1	10/1/93	30			2				5/24/96	2
121		67969-1	1961	7/24/75	2	1	1/1/94	36			2				6/5/96	6
122		06994-1	1970	12/26/69	2	1	1/2/94	48			1				9/1/96	13
123		06296-1	1931	9/12/61	1	1	4/1/96	36			2				4/1/98	6
124		62476-1	1707	7/6/73	1	1	3/24/96	32			4				12/1/98	2
125		06993-1	1703	3/6/66	2	1	9/7/93	37			2				1/15/98	6
126		06316-1	1772	8/19/61	1	1	9/13/93	33			1				1/26/98	4
127		61996-1	1761	4/24/73	2	1	9/12/93	31			1				1/6/98	4
128		06199-1	1742	8/26/66	2	1	9/13/96	13			1				11/1996	2
129		61472-1	1748	8/17/66	1	1	6/2/93	36			2				11/7/96	6
130		67944-1	1762	4/17/66	2	1	6/6/93	11			1				9/11/96	2
131		06996-1	1537	8/26/73	1	1	9/29/91	46			2				8/3/95	6
132		67618-1	1636	4/14/62	2	1	10/5/92	36			1				9/1/95	4
133		06736-1	1726	9/12/66	1	1	9/7/92	37			1				11/8/95	2
134		67163-1	1731	3/13/61	1	1	9/29/93	6			1				9/29/95	0
135		06986-1	1711	3/2/73	1	1	12/4/91	32			2				5/8/95	4
136		06342-1	1638	3/11/75	1	1	9/13/92	36			2				9/7/95	6
137		06134-1	1721	6/6/666	2	1	9/7/96	36			6				9/20/95	6
138		67566-1	1713	9/7/73	2	1	9/14/93	36			1				9/13/96	4
139		06993-1	1719	2/3/61	2	1	9/22/93	36			1				9/13/96	3
140		06316-1	1744	1/2/66	1	1	9/13/93	16			2				9/6/95	6
141		06396-1	1618	12/15/61	2	1	12/14/92	22			2				9/13/96	6
142		06996-1	1662	9/13/66	2	1	11/2/93	19			1				3/5/96	6
143		61576-1	1661	3/24/63	2	1	9/2/9666	36			1				3/6/95	2
144		67676-1	1778	6/26/73	1	1	11/24/93	17			1				9/7/96	6
145		67566-1	1776	6/9/666	1	1	7/6/93	36			1				1/6/966	4
146		06996-1	1762	9/6/1961	1	1	9/24/96	36			2				9/6/96	6
147		61174-1	1736	1/26/76	2	1	9/16666	37			1				7/6/1962	6
148		06394-1	1736	6/26/73	2	1	1/26666	36			1				4/14/962	6
149		06666-1	1767	9/26/75	1	1	9/27/96	36			3				7/26666	6
150		06396-1	1744	6/25/73	2	1	11/7/96	36			1				6/16962	13
151		06234-1	1748	11/19/73	2	1	3666	36			2				9/12963	6
152		06194-1	1766	3/26/76	1	1	6666	46			3				9/19962	6
153		06172-1	1718	9/6/77	2	1	9/19966	23			1				9/6/962	6
154		06666-1	1767	9/10/74	1	1	9/1/96	31			6				9/4/96	6
155		06966-1	1764	11/26/75	2	1	9/17/96	36			2				9/26962	4
156		04316-1	1761	9/13/73	2	1	9/6/96	13			1				9/6/962	4
157		06666-1	1774	1/6/76	2	1	9/26961	43			2				9/27/96	4
158		61566-1	1661	6/6/76	1	1	9/26966	44			1				1/24962	4
159		06634-1	1731	9/19/76	1	1	9/26966	37			1				9/1962	2
160		06666-1	1762	9/12/76	2	1	6/4/96	34			2				7/3/962	6
161		06966-1	1671	9/19/76	1	1	4/21/96	36			2				1/2962	4
162		61774-1	1672	7/19/74	1	1	9/26966	23			1				1/2962	4
163		06516-1	1767	6/6/73	2	1	9/27/96	16			1				1/26962	6
164		06666-1	1743	10/10/76	1	1	9/14/96	13			1				12/1962	2
165		06373-1	1736	12/1/76	1	1	9/26966	33			6				11/26962	4
166		06726-1	1761	2/26/76	2	1	6/6/966	32			2				10/1962	6
167		06963-1	1763	4/6/71	1	1	9/1/966	33			1				10/1962	3
168		06666-1	1666	11/26/76	1	1	9/26961	36			2				11/1962	6
169		06666-1	1727	7/26/76	1	1	1/26961	13			1				7/1962	2
170		06736-1	1722	6/23/76	1	1	9/1/966	36			1				1/1962	3
171		06726-1	1766	9/6/76	1	1	1/26961	37			1				10/2962	6
172		06194-1	1633	7/6/76	1	1	10/1961	22			6				9/6962	6
173		06662-1	1667	7/26/73	1	1	11/6961	33			1				1/22962	4
174		62424-1	1666	1/24/66	1	1	4/1961	33			2				10/1962	2
175		06666-1	1667	10/21/66	2	1	3/26961	34			1				1/6962	6
176		06734-1	1666	10/14/76	2	1	4/19961	37			1				4/2962	6
177		06652-1	1643	6/26/76	2	1	3/22961	37			2				12/1962	4
178		06666-1	1667	7/6/76	1	1	11/2966	41			1				9/6/962	4
179		61796-1	1643	10/26/77	1	1	1/26966	36			1				9/6962	4
180		61966-1	1614	4/23/76	1	1	1/26966	16			1				12/1962	4
181		06662-1	1666	10/17/76	1	1	3/1961	36			2				9/1/96	2
182		61196-1	1667	9/10/76	1	1	1/6961	40			2				9/1/966	4
183		67964-1	1674	11/4/61	2	1	6/21/63	36			2				12/1/962	6
184		61966-1	1666	6/27/77	2	1	10/2/966	36			2				9/6962	4
185		06436-1	1636	6/6/76	1	1	2/1966	17				1			9/2966	2
186		06666-1	1666	10/22/76	2	1	9/26962	33			2				10/1966	0
187		06666-1	1643	9/1/66	1	1	9/2962	43			1				1/6962	2
188		61576-1	1632	1/26/76	2	1	1/6961	7			1				9/27/96	2
189		06736-1	1661	3/19/61	1	1	10/26961	36			2				9/2966	4
190		61966-1	1666	1/6/76	2	1	1/1966	34			2				9/2966	0
191		04966-1	1643	6/6/66	1	1	9/2966	36			4				9/21961	2
192		62424-1	1642	1/26/61	2	1	1/6961	11			1				9/1/964	4
193		06394-1	1666	9/27/76	1	1	1/1962	36			2				9/1/964	6
194		04366-1	1662	6/23/73	1	1	4/6961	36			1				7/1966	2
195		61176-1	1619	12/3/73	1	1	3/11961	36			1				9/2963	1
196		06662-1	1646	6/6/73	2	1	9/19961	36			3				6/6964	4
197		06714-1	1643	9/15/77	1	1	9/1962	36			4				12/1964	2
198		61966-1	1666	11/26/76	1	1	3666	13			6				9/2963	2
199		62663-1	1643	7/3/76	2	1	3666	19			1				1/6963	6
200		06196-1	1679	3/6/77	2	1	4/6966	36			2				10/2963	4
201		61196-1	1643	9/16/73	1	1	9/1/961	11			1				9/1966	6
202		61964-1	3	6/2966	1	2	3/1962	22	7/1/63	head gear	2	16	36	7/1/66	9/1964	6
203		06612-1	6	3/7/73	2	2	9/1966	36	6/2964	Ling Hdrs, ba	3	6	17	9/24961	12/1966	13
204		06316-1	66	7/15/74	1	2	9/1962	46	7/21/67	Cranial plasmi	3	6	34	7/17/67	4/7/66	4
205		61426-1	63	12/26/73	1	2	6666	16	11/1966	expander	1	7	13	11/1966	1/14/67	2
206		06214-1	64	11/14/70	2	2	6/2963	36	11/7966	hg	2	16	36	11/1964	6/6967	6
207		61726-1	218	4/26/72	2	2	9/2963	13	1/7/66	prev hg	4	16	19	1/7/65	12/22/66	2
208		67113-1	262	8/1/73	1	2	9/1966	17	3666	prev hg	2	9	9	7/666	6/26967	7
209		61536-1	266	12/26/72	2	2	9/7/63	22	6/7/66	anneal hg	2	9	26	6/7/66	9/7967	6
210		06726-1	268	6/7/76	2	2	9/17/63	33	9/1/966	integolev	2	9	30	6/1/966	9/1966	6
211		06726-1	116	8/21/74	2	2	6/2963	36	9/2966	pedal pair	2	10	21	9/2963	9/1966	3
212		06716-1	422	9/26/76	2	2	3/6966	36	6/2966	hg	3	9	26	9/2966	11/26961	2
213		06666-1	441	1/21/72	2	2	7/17/66	36	9/2966	palatocolic, TPX	4	11	19	9/2966	12/1966	6
214		61576-1	401	9/26/72	1	2	9/14/66	27	1/1966	Sky 4	3	10	15	9/1966	7/1/66	6
215		06666-1	631	6/6/76	2	2	6-Jun	36	11/2967	3 lgd	1	10	6	11/2967	12/2966	2
216		06666-1	512	1/1/74	2	2	1966964	17	12/2966	2lgd	1	9	13	12/2966	6/6966	6
217		61126-1	643	9/26/76	2	2	7/2966	46	6/6/67	bonded lgd	4	6	16	6/6967	6/6966	2
218		63563-1	664	6/13/72	1	2	9/14/66	33	9/1966		4	11	30	9/1966	3/2966	22
219		61036-1	731	3/13/73	2	2	6/2963	20	6/6967	recare	2	10	16	6/2967	12/1966	6

APPENDIX 3. Raw data



APPENDIX 3. Raw data



APPENDIX 4. IRB approval

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

TO: **Hans, Mark G.**
Katzan, Charissa Sylvia

Dept/School: **Dentistry**

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

The committee has reviewed and approved your proposal entitled: **Outcome Assessment of Two Phase Orthodontic Treatment Relative to One Phase Treatment Using the PAR**

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

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

Follow-up: The Committee wishes to have a status report on this project on **10/16/1998**

SIGNED FOR THE COMMITTEE BY:

Approval Date:
10/30/1997

Charlotte L. Horton
Director
Office of Research Administration

CZ

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

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

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

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

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

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