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We hereby approve the thesis of

Roland Labib Feghali

candidate for the degree Master of Science

in Dentistry.

Signed: Suchitra Nelson
(Chairman)

Date: August 13th, 1999

COMPARING INTRAORAL CLINICAL OBSERVATION WITH STUDY MODEL ASSESSMENT OF OCCLUSION USING THE PAR INDEX

by

ROLAND LABIB FEGHALI

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Thesis Advisor: Dr. Suchitra S. Nelson

Department of Orthodontics

School of Dentistry

CASE WESTERN RESERVE UNIVERSITY

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Abstract

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Traditionally, the Peer Assessment Rating (PAR) index has been used on dental study models. The present study enrolled sixty-three orthodontically treated patients, recalled to the graduate orthodontic clinic at Case Western Reserve University for retention appointments. The PAR occlusal index was used to measure the occlusion in three different ways. First, directly by intraoral examination, second utilizing trimmed orthodontic study models derived from alginate impressions taken by a dentist, and third using study models derived from patient administered impressions. Other demographics, such as patient's age, date of birth, gender, and temporomandibular joint dysfunction (TMD) status were recorded. The mean intraoral, alginate, and polybite-polyvinylsiloxane PAR scores were 8.2 $\pm$ 4.5, 9.1 $\pm$ 4.7, and 8.3 $\pm$ 4.6, respectively. Statistical comparison of the intraoral and alginate impressions techniques were significant ($p \leq 0.05$) for differences in total PAR score and left buccal occlusion segment. Therefore,

we conclude that traditional alginate impression with registration wax-bite remains the most accurate method for assessment of occlusion.

DEDICATION

To my father, mother, and family

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INTRODUCTION

With a worldwide social and economical development, focus on personal appearance influenced by television and other media has been on the rise (Gottlieb 1975, 1984). Orthodontics is the specialty of dentistry that deals with the treatment of crooked and malpositioned teeth in relation to their supporting structures. These are referred to as malocclusions. The word *occlusion* refers to "the manner in which the teeth intercuspate" (Moyers 1956), while the word *malocclusion* is commonly used to indicate occlusal disorders (Summers 1971). The difference between occlusion and malocclusion falls somewhere in the continuum between normal variation and deviation (Foster and Menezes 1976). Data from the third National Health and Nutrition Examination Survey (NHANES III), analyzed by Proffit et al. (1998) using the Index of Treatment Need, revealed that 58% of the United States population was in need of orthodontic treatment. Given an ever-increasing need for orthodontic therapy, there is value in a quick and valid way to evaluate and assess occlusion/malocclusion.

In recent years, there has been an increased interest by both government and insurance agencies with regard to the efficacy of orthodontic treatment in correcting dental malocclusion. This has resulted in the

development of occlusal indices. Occlusal indices are descriptions or measurements taken either from observation of dental study models or directly from a patient's dentition. The use of occlusal indices in the assessment of malocclusion reduces subjective bias, is acceptable to both clinicians and patients, and yields quantitative data.

Traditionally, occlusal indices have been derived from experimentation of dental study models. It would be desirable to know if these indices, which have been field tested and proven to be reliable and valid on study models, can be determined directly that is intraorally, and if so, whether the results are comparable with those obtained from study models. This could provide a practical method for data collection and a quick assessment of occlusion during field studies, without the use of study models. To test this, the Peer Assessment Rating (PAR) occlusal index will be used to measure and assess the occlusion of sixty-three orthodontically treated patients, recalled to the graduate orthodontic clinic at Case Western Reserve University for routine retention check-up appointments. The patients occlusion will be assessed using the PAR index determined by direct intraoral examination and from two different sets of study models.

REVIEW OF THE LITERATURE

Classification of Malocclusion

Grading and classifying malocclusion has been practiced for over a century. Most classifications and studies on the epidemiology of malocclusion have been qualitative and subjective. In 1899, Edward Angle, the father of Orthodontics, wrote:

> "The dividing line between harmony and inharmony of occlusion is often very slight...The best balance, the best harmony, the best proportions of the mouth in its relation to other features require that there be the full complement of teeth, and that each tooth position shall be made to occupy its normal position-normal occlusion".

Angle used qualitative assessment of malocclusion in his classification. He described in minute detail each contacting cusp incline to prove his point that in ideal occlusion every tooth should have two antagonists. He classified occlusion on the basis of anteroposterior relationships of the jaws. However, Van Loon (1915) published criticism of Angle's classification and proposed an improved technique for trimming plaster study models, so that the true relationship of the teeth to the soft tissue of the face could be evaluated. Thus, Angle's classification was devised as a pre-treatment assessment and not as an epidemiological tool.

In 1915, Dewey distinguished between "positions of malocclusion" and "classes of malocclusion". He referred to "positions of malocclusion" as to the position of the individual teeth in relation to the line of occlusion and the median line of the face, whereas "classes of malocclusion" referred to the relation of one dental arch to the other. He emphasized the importance of dividing malocclusion upon the antero-posterior relation of the dental arches, taking into consideration each arch as a whole and not any one tooth. He concluded by saying that one will find that each and every case of malocclusion will fall in one of the three groups, previously classified by Angle as either class I or class II or class III, which will, therefore, simplify diagnosis, treatment, and post-treatment evaluation.

Simon (1924) related the dental arches to the Frankfort, orbital, and mid-sagittal planes. He attempted a canine-focused classification. His law of the canine considered the orbital plane as coincident with the distal third of the maxillary canine in ideal occlusion. Moore (1948) classified malocclusion in terms of the time required for treatment.

In 1951, Elsasser developed the facial orthometer that measured dentofacial morphology. The same year, Massler and Frankel introduced a quantitative method of assessing malocclusion, where each tooth was classified as missing, malposed, or in proper position. The total number of displaced or rotated teeth was the basis for the evaluation of malocclusion in a population group.

Van Kirk and Pennell (1959) developed "the malalignment index" of teeth. They performed intraoral examinations on 2,100 children between twelve and fifteen years of age. Each tooth present in a segment was scored as in ideal alignment, minor rotation or displacement, and major rotation or displacement. Although the malalignment index was shown to be rapid and simple in its application, there seemed to be a progressive increase in average scores. The increase was three times greater in the posterior than the anterior areas of the mouth.

Recording Malocclusion

Angle's (1899) classification of malocclusion has been the most commonly used method for assessing malocclusion. However, many other methods and indices have been proposed in the recent years, since there is no widely accepted quantitative method for assessing malocclusion.

It is a basic requirement of any index of measurement to be valid and reproducible. Validity is the ability of an index to measure what it purports to measure, whereas reproducibility is the ability to measure the same ratings or scores when the subject is reexamined by the same or different examiner. Massler and Frankel (1951) reported that in order to get reliable information on the prevalence of malocclusion, the technique of investigation and registration should be simple, reproducible, and would yield quantitative information allowing for statistical analysis.

Little (1975) stated that "epidemiological studies comparing the presence and amount of various characteristics of occlusion would benefit from a quantitative measure of severity of dental irregularity". Betteridge (1976) reported that an index for measurement of crowding and malocclusion assessment should be reproducible and numerical.

Rudge et al. (1983) compared three methods of arch analysis, using six sets of study models analyzed by three observers to assess the reproducibility of these methods. They found variability between different methods of measuring arch discrepancy described and between the examiners employing these methods. They concluded that different methods cannot measure exactly the same dimensions, and that high degree of accuracy was required to provide more sophisticated information about the occlusion.

The need for a valid and reproducible occlusal index is indicated for fast and accurate data collection, clinically and/or from the patient's dental records. Such an index should be easy to learn and use by dental and possibly nondental personnel.

Historical Intraoral Assessment of Malocclusion

Correct alignment of teeth has been, and continues to be, a fundamental objective in orthodontic treatment. That goes along with an accurate diagnosis of space requirements. Together, they form essential

elements in orthodontic treatment planning. Therefore, a visual assessment of malocclusion using some sort of occlusal index would aid in this process.

Various direct intraoral measurements of the dental arches have been used in the past. However, they were mostly limited to one particular region of the mouth. Lundstrom (1955) studied the significance of early loss of deciduous teeth in the etiology of malocclusion. He did not find any influence by the early loss of deciduous teeth on the developing dentition. However, his conclusion was based solely on clinical observation, with no reference to any standard assessment.

Other investigators were more specialized in their assessment of malocclusion. Breakspear (1951) and Gardiner (1975) performed intraoral measurements of the posterior regions; Haynes (1972), Foster and Day (1974), Todd (1975), then Jimenez (1975) were able to assess malocclusion intraorally of the anterior region of the mouth. However, these assessments were by simple observation, and limited to only one region of the mouth, either anterior or posterior. These assessments did not use any occlusal index, which might have added precision and standardization and removed subjectivity from the evaluation.

In a study reported by Scivier, Menezes, and Parker (1974) the Treatment Priority Index (TPI) was used clinically. Ratings were obtained from two separate studies of one hundred children each. A validity correlation of 0.65-0.71 was reported. This led to the conclusion that the TPI

was extremely promising and a reliable objective method of assessing malocclusion.

Caveney (1976) reported a study in which Handicapping Malocclusion Assessment Record (HMAR) scores obtained from dental casts were compared with intraoral assessments of one hundred patients. He concluded that the index provided a valid measure of the severity of malocclusion.

More recently, Kinaan and Burke (1981) developed a method in assessing occlusion where they performed measurements on study models and directly on a number of orthodontic patients. An overbite gauge was devised along with overjet and crowding of teeth measuring instruments. Each dental arch was divided into three segments; an incisal segment and two buccal segments. Each segment was then assessed in terms of intra-arch alignment and inter-arch relationship. Their numerical values from study models were smaller than the actual values, due to the difference in thickness between the plaster material on the study models and the dental units intraorally.

Occlusal Indices

Popovich and Thompson (1971) described the difficulty in quantifying the degree of malocclusion. One can assess it only by measuring the relationship of the teeth to each dental arch individually and their interaction with the maxillary and mandibular arches simultaneously.

In the orthodontic context, an index is used to describe a rating or categorizing system that assigns a numeric score to a person's occlusion. There are several indices that assess malocclusion both intraorally and extraorally. Further, these are divided into treatment need and treatment outcome indices. They will be briefly described in the sections below.

Treatment Need Indices

Many indices have been developed with the intention of categorizing malocclusions according to the level of treatment need and to record prevalence in epidemiological studies. Angle's classification is the best known type of treatment need indices. Its subclasses are often being used to describe incisor and buccal segment relationships separately; they serve their purpose reasonably well, allowing ease of communication between orthodontists. Yet, Rinchuse and Rinchuse (1989) argued the confusion in relying solely on Angle's system of molar classification. They found "Angle" to be limited because it is a system of discrete classes vis-à-vis a continuous system. They went on to say that Angle was not clear about the description and definition of his classes and his writings were equivocal, leading to the possibility of one class overlapping into another. First, Angle wrote that all teeth should be considered when classifying cases; then few years later his emphasis was on the maxillary first molars as reference teeth only. With regard to diagnosis and treatment, Angle assumed all malocclusions that looked alike to be alike, which is not true. Because of this confusion and lack

of reliability in using Angle's classifications, it was suggested that the American Association of Orthodontists and the American Board of Orthodontics define and interpret Angle's classification in a way that is less subject to error.

In 1960, Draker developed the Handicapping Labiolingual Deviation index (HLDI) to separate the most severe labio-lingual deviations from lesser orthodontic conditions. The index was shown to be simple, objective, reproducible, and can be applied to both patients and models. That same year Grainger developed the Malocclusion Severity Estimate index (MSE), in the Burlington Research Center in Canada, used on study models or on patients. The MSE was later revised to become the Treatment Priority Index (TPI).

In 1966, the Handicapping Malocclusion Assessment Record (HMAR) was developed by Salzmann in response to a recommendation by the American Dental Association's Council on Dental Health. The index was designed for the purpose of identifying any occlusal conditions that interfere with oral health or general well being. This method was quick, did not require millimeter measurements, and was valid for examination of large numbers of children. During its development, the HMAR was tested by orthodontists from various parts of the United States. They found a high correlation between subjective clinical ratings and scores obtained from the dental study models of the same subjects. However, Byrne (1968) noticed that there was an inter-

examiner variability of about 5% when the HMAR was used directly with the patient than indirectly with study models.

In 1971, Summers introduced the Occlusal Index (OI) which was used in epidemiological studies and to determine treatment need. Nine occlusal characteristics were scored using this index: dental age, molar classification, amount of overjet and overbite, posterior transverse and vertical problems, tooth displacement, missing teeth, and midline alignment. A score for each of these components was derived then weighted to calculate an overall score.

All of the three previous indices, the Handicapping Malocclusion Assessment Record (HMAR), the Occlusal Index (OI), and the Treatment Priority Index (TPI), were compared by Grewe and Hagan (1972) for their precision in assessing malocclusion. The study sample consisted of 130 dental study models taken from pretreatment records of patients ranging in age from eleven to fifteen years old, scored by three different examiners. It was concluded that the OI had the highest correlation of the three indices and was the index of choice with regard to having the least amount of bias.

Another study by Gray and Demirjian (1977) compared the reproducibility and accuracy of four occlusal indices in assessing malocclusion, in anticipation of government-sponsored orthodontic treatment. These indices were the Handicapping Labio-Lingual Deviation (HLD) Index of Draker, the Treatment Priority Index (TPI) method of Grainger, the

Occlusal Index (OI) method of Summers, and the AAO Handicapping Malocclusion Assessment (HMA) developed by Salzmann. Intraoral assessment of malocclusion was performed on patients. The HMA method was found to be highly reproducible and sensitive over the entire range of occlusions. It required only a mouth mirror and dental explorer in the assessment, since only full-cusp discrepancies were noted, once the method was learned, no actual recording form was needed. This method closely resembled the use of the DMF Index. However, only when the occlusal relationship of erupted teeth was taken into account, the subjective evaluation of the degree of need for occlusal correction would show variation if judgments were made in an unbiased situation.

Bjork et al. (1964) introduced an instrument for the evaluation of malocclusions. It was used during epidemiological investigation for the prevalence of malocclusion and need for orthodontic therapy. This method consisted of a systematic registration of carefully defined features assessed using a specially designed instrument. It included a handle with blades of certain thickness, used in the measurement of overjet, overbite, spacing, and transverse discrepancies. Although this method was appropriate for direct intraoral patient evaluation and/or study model assessment, it was very detailed and required a long time in assessing the malocclusion.

A simpler method of assigning treatment need was to establish a list of conditions or traits in categories that denoted the extent to which treatment

was considered necessary. The Swedish National Board for Welfare Index was developed in this manner. It determines whether or not a patient's malocclusion falls within the scope of treatment in the Swedish public dental services. Although this index used direct intra-oral evaluation of the malocclusion, it was never tested on dental study models to compare its accuracy from direct and indirect measurements.

While evaluating malocclusion in children, Gupta (1967) outlined an index applied directly in the mouth. It used arbitrary quantitative weightings, large for overbite, overjet, crowding, and spacing, and small for the posterior relationships. However, this index was not tested on dental study models.

Shaw et al. (1987, 1989, and 1991) developed the Index of Orthodontic Treatment Need (IOTN). This index ranks malocclusion in terms of the significance of various occlusal traits for the person's dental health and perceived esthetic impairment, with the intention of identifying those persons who would be most likely to benefit from orthodontic treatment. The index incorporates a dental health and esthetic component. It may be applied both clinically and to study models. Although found to be valid and reproducible, the IOTN has not been applied extensively to different population groups, and experiences in using it are still very limited.

Treatment Outcome Indices

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

Summers' Occlusal Index

Described previously under treatment need indices section, Summers' Occlusal Index (OI) (1971) was also used to determine treatment quality and outcome. When used intraorally, this index had different scoring schemes and scoring forms for patients in different stages of dental development, i.e., deciduous dentition, mixed dentition, and permanent dentition. When applied on dental study models, this method seemed to be tedious. The system was more appropriate for scoring pre-treatment rather than post-treatment study models.

The Peer Assessment Rating (PAR) Index

From the 1970's through the early 1990's, the variation in criteria used by different orthodontists made it difficult to assess orthodontic treatment outcome. Richmond et al. (1992) developed the Peer Assessment Rating (PAR) index to record the dental malocclusion at any developmental stage, while using a precise quantitative method of measuring malocclusion and efficacy of treatment. A scoring system was developed and a ruler designed to allow analysis of a set of study casts in approximately two minutes.

The PAR index is applied to an individual's study models. It estimates deviations from an ideal occlusion. Scores are assigned to the various occlusal traits that make up the malocclusion. The individual scores are summed to obtain a total that represents the degree a case deviates from normal alignment and occlusion. The score of zero indicates good alignment and higher scores indicate increased levels of irregularity. Using the PAR ruler, numeric numbers are given to the segments of both upper and lower dental arches which make up this index. These segments are as follow:

Upper anterior segment (from mesial of right cuspid to mesial of left cuspid)

Right Buccal Occlusion (from cuspid to most distal permanent molar)

Left Buccal Occlusion (from cuspid to most distal permanent molar)

Overjet (amount of horizontal overlap and anterior crossbite)

Overbite (extent of vertical overlap along with any openbite)

Centerline (in relation to lower central incisor width)

Although it made use of the basic premises of Angle's classification and categories, the PAR index reliability is superior to Angle's classifications. It includes more defined criteria, while still requiring only a small amount of time during the assessment.

Several studies were conducted to evaluate the PAR index validity and reliability. Richmond et al. (1992) discussed the reliability of the PAR index, exhibited within and between examiners. They defined this index as a

tool that "offers uniformity and standardization in assessing the outcome of orthodontic treatment". Its components were weighted to reflect current British orthodontic opinion, however they could be changed to reflect future standards and standards used in other countries, such as the United States.

Buchanan et al. (1993) also evaluated the reliability of the PAR index by looking at the same sample originally used by Richmond et al. in 1990, when the index was developed, and compared it with the Summers occlusal index. They found the reliability and validity of the PAR index to be similar to the Summers index. The fact that PAR index was simpler and easier to use than the complicated Summers occlusal index did not diminish its validity and reliability.

DeGuzman et al. (1995) carried out a study to examine the reliability and validity of the PAR index by using the opinion of an American panel of orthodontists. Eleven orthodontists examined a sample of two hundred sets of study casts and rated them for malocclusion severity and perceived treatment difficulty. Multiple regression techniques were used to evaluate the predictive power of the components of malocclusion on the panel's scores. Weightings were calculated from the partial regression coefficients and, when these weightings were applied to the PAR index, the association between the panel's opinion and the PAR index scores increased. As a result, the PAR index was considered to represent a good approximation of

malocclusion severity and treatment difficulty, and could be used as an outcome measure for the assessment of dento-occlusal changes.

The ABO Objective Grading System

In 1998, the American Board of Orthodontics (ABO) introduced their Objective Grading System. This precise method for orthodontic treatment evaluation was field tested for objectivity in evaluating post-treatment dental casts and panoramic radiographs. It consists of a measuring gauge specially designed to detect for discrepancies in alignment, overjet, occlusal contact, interproximal contacts, and occlusal relationships. The Board plans to market this gauge in the near future. The Board encourages clinicians to use this system to determine if the orthodontist has been producing "Board quality" results. It is an effort to elevate the quality of orthodontic care. However, this method can not be used intraorally yet, and the measuring gauge is not available for general public use. It is still limited exclusively to the examiners of the American Board of Orthodontics.

Unlike the previously described tools, which lack intra-oral testing and validity, the PAR index is simple, reproducible, valid, inexpensive, and an easy to use tool for assessing malocclusion when applied on study models. However, up until now, no one has used it for direct intraoral assessment of malocclusion.

Various Applications of the PAR Index

Several studies have been conducted in order to explore the usefulness of the PAR index as a means of assessing malocclusion and differentiating the change associated with or without orthodontic treatment. McGuinness and Stephens (1993) used holograms in assessing malocclusion. Thirty sets of orthodontic study models were selected from the model stores of a clinical orthodontic department. A full range of malocclusion was represented including severe overjets, overbites, crowding, spacing, open-bites, and cross-bites. Holograms were prepared from the study models from four different views taken from each set of models: An occlusal view, right and left buccal views in occlusion, and a frontal view also in occlusion. Using a special laser holographic camera system, the images were projected and viewed using a visible light viewer. The study models and their corresponding holograms were then scored using the PAR index. They concluded that significantly lower scores were obtained from the holograms, which were ascribed to lower anterior alignment, overjet, and centerlines, three of the components that make up the PAR index. Thus, the PAR index, when applied to holograms of study models under-estimated the severity of the malocclusion compared to the original study models.

Otuyemi and Jones (1995) used the PAR index to evaluate treatment and long-term, post-retention results obtained from fifty class II division 1

malocclusion cases. Dental study models were used to record the occlusion pre- and post-treatment, as well as one and ten years post-retention. The results suggested a high treatment standard, as indicated by mean percentage PAR score reduction. However, maintenance of post-treatment results one and ten years post-retention was only achieved in 60% and 38% of cases, respectively. Late lower anterior crowding appeared to be the major factor involved in this deterioration.

Afsharpanah et al. (1995, 1996) assessed the effects of normal growth and development on the PAR index scores, by looking at study models of orthodontically untreated subjects enrolled in the Bolton-Brush Growth Study. Their results showed that no subjects at any time during their normal growth and development demonstrated a significant natural reduction in PAR scores.

Feghali et al. (1995, 1996, and 1997) used the PAR index to assess orthodontic treatment outcome, where pre-treatment and post-treatment study models from the graduate orthodontic clinic at Case Western Reserve University (CWRU) were evaluated. Similarly, Hassanein et al. (1996), Mehdizadeh et al. (1997), Beg et al. (1998), and Abei et al. (1999) also used the PAR index in assessing treatment outcome. All these studies showed "improvement" in the cases at CWRU, where only 4% of the cases treated did not achieve over 30% reduction in PAR scores.

Buchanan et al. (1996) used the PAR index to determine differences in outcome between the pre-adjusted Edgewise and Begg treatment techniques at the time of debonding. They noticed that a simple comparison of the percentage reduction in PAR score may be misleading, and careful interpretation of the results is necessary.

Weiland et al. (1997) compared occlusal deviations in the permanent dentition in the skulls of ninety-four nineteenth century and 157 present-day Austrian males using the PAR index. It was concluded that secular changes in malocclusion have occurred during the last one hundred years, where the contemporary dentitions showed significantly higher PAR scores than the nineteenth century sample.

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

Richmond et al. (1997) used the IOTN and PAR index to assess treatment complexity. The concept of complexity is related to the occlusal changes which occur during orthodontic treatment. The views of 280 practitioners towards recently completed orthodontic treatment were collected. They concluded that attempts to define treatment complexity

identified factors which were of questionable validity and easily manipulated in the practice setting.

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

Evaluation of Malocclusion and Position of Teeth

Vlachos (1995) referred to "ideal occlusion" as a theoretical concept based on the morphology of the teeth and is rarely found in nature; whereas "normal occlusion" allows for minor variation from the ideal, which is esthetically satisfactory and functionally acceptable. He went on to say that patients with malocclusion might exhibit normal occlusal function, whereas dysfunction can occur in patients with anatomically ideal occlusion.

In evaluating malocclusion, study models are commonly used in the assessment. Study models have been essential clinical records in orthodontics and a standard way to evaluate the articulation and position of teeth. However, a study by Han et al. (1991) claimed that study models

alone provided adequate information for orthodontic diagnosis in only 55% of cases.

When PAR scoring a set of dental study models in centric occlusion, one would expect a relatively lower score than when scoring in centric relation, because the condyles will be seated superiorly and anteriorly from centric occlusion to centric relation. This will, therefore, alter the occlusion, especially in the overjet and buccal segments' components, leading to either higher or lower PAR score.

Proffit (1993) defined the goal of modern orthodontics as "the creation of the best possible occlusal relationships within the framework of acceptable facial esthetics and stability of result". For the latter to be true, a repeatable position in the relationship of the upper and lower teeth is necessary. This would indicate the presence or absence of premature occlusal interferences, and/or possible temporomandibular dysfunction symptoms. Ramfjord and Ash (1971) considered occlusal interferences to be important in the etiology of temporomandibular disorders.

Timm et al. (1976) discussed the characteristics of an ideal occlusion, while considering functional aspects as well as static concepts. They stated that there should be a stable jaw relationship when occlusal contact is made in centric relation, and centric occlusion should be at the same contact vertical dimension as centric relation. The final occlusion on an orthodontically treated patient should provide unhindered closure in centric

relation and an optimal bilateral vertical contact dimension. This could be accurately accomplished in most instances by proper occlusal adjustment following orthodontic therapy.

Parker (1978) defined centric relation as a situation in which the head of the condyle of the temporomandibular joint, at rest, is in a position where all of its attending muscles and ligaments are at rest. It is very often more distal than centric occlusion in many patients, and may or may not coincide with the position required to place all of the teeth in centric occlusion. For many clinicians it is prudent to place study casts on some adjustable articulator in centric relation to see if this coincides with centric occlusion. At the same time, it is easy to observe clinically how the teeth interact in the various excursive movements.

While most orthodontists consider posterior interdigitation of teeth to be their treatment goal, few are committed to a cusp-fossa concept where they carefully consider the relationship of the lingual cusps of the upper posterior teeth to the fossae of the lower posterior teeth as well as the more readily observed buccal relationships. Moffett (1978) argued that centric relation position is physiologically desirable and is an acceptable reference position for treatment. The same year, Aubrey presented a means for preventing the temporomandibular joint pain-dysfunction syndrome. He recommended that each orthodontically treated case should be finished with the teeth in centric relation. He also emphasized the importance of

equilibrating the occlusion of every completed case to eliminate the minute occlusal interferences, which are always present.

Williamson (1981) insisted that temporomandibular disorder symptoms such as muscle pain, joint noise, and headache could occur if a centric discrepancy exists after orthodontic treatment. Roth (1981) concluded that attainment of "centric relation occlusion" as the key to successful orthodontic treatment in terms of stability of result as well as for the prevention of temporomandibular disorders.

Solberg and Seligman (1985) considered a small "slide in centric" at the completion of orthodontic treatment to be a rather normal phenomenon; however, they cautioned against asymmetric CR-CO slides especially when these are coupled with unilateral premature contacts in centric relation.

Pullinger et al. (1988) studied the association between mild signs of temporomandibular disorders and dental occlusal morphology in a 253 non-patient population. They concluded that 10% of the subjects had 1 mm or greater slide between centric relation and centric occlusion.

Johnston (1988) evaluated ninety-two subjects two weeks off deprogramming with an occlusal splint. All subjects received comprehensive orthodontic treatment prior to that, and had an average centric slide that was comparable to an untreated control group. He concluded that for modern man a CO-CR difference may be normal, physiologically significant by-product of the nature and pattern of mandibular function and the tooth

attachment mechanism. Therefore, moderate changes in the magnitude of a given patient's centric slide would be expected to regress to the CO-CR difference that was present before treatment.

Walls et al. (1991) compared the accuracy of two different techniques in mounting dental casts in the intercuspal position (ICP) on a semi-adjustable articulator. The techniques consisted on using a polyether interdental registration, or simply by tactile and visual methods. They concluded that hand articulation of the dental casts prior to mounting the lower cast against the upper cast was a more accurate means of locating the ICP than using the polyether interdental registration material.

Hwang and Behrents (1996) investigated the effects of orthodontic treatment on centric discrepancy, where thirty-six orthodontically treated patients were compared with thirty persons who have never received orthodontic therapy. They concluded that the orthodontic treatment group had the same amount in centric discrepancy as the non-orthodontically treated sample.

Gaither et al. (1997) compared condylar position between centric occlusion (CO) and centric relation (CR) for twenty-four adolescent orthodontic patients at pre-treatment, post-treatment, and during the retention phase of orthodontic treatment. They concluded that the mean three-dimensional distance between CO and CR tended to increase from pre-treatment to the retention phase for the right and left sides, with the left

side showing a greater increase. This difference could be the result of changes in the CO-CR relationship, examiner reliability, or a combination of both.

Clark and Evans (1998) investigated features of the functional occlusion in a group of thirty-seven patients immediately following full orthodontic therapy. Dental study models were mounted on a semi-adjustable articulator in the retruded axis position. Occlusal contacts were recorded with articulating paper in retruded and lateral mandibular positions. The results revealed that the majority of subjects had a unilateral contact on initial closure in the retruded axis position, a slide between this position and the intercuspal position, and contact between the second molars on the non-working side. Thus, these patients did not exhibit ideal occlusal relationships, which could be due to post-orthodontic instability, tooth wear, and temporomandibular disorders.

Le (1998) conducted a study from a sample of 1,360 tenth grade students enrolled in Cuyahoga County, Ohio public high schools to estimate orthodontic utilization rate and treatment outcome. Polybite trays, along with a silicone putty material, were used as a basis for evaluation. Dental study models for a sub-sample of 149 students were then scored to assess outcome using the PAR index. Interestingly, when scoring the study models, it was necessary to hand articulate them to a "best fit" since there was no

wax bite taken at the time of data collection. Thus, the potential for errors was possible.

Some studies found centric relation to be coincident with centric occlusion following orthodontic treatment, while others urged for equilibration of the dentition to eliminate occlusal interferences and therefore the slide between the two jaw positions. Yet, there was no evaluation of the different methods in taking impressions, which might have an influence on how the upper teeth relate to the lower teeth. This procedure is not routinely followed since it is time consuming and not a prerequisite in diagnosis and treatment planning. However, there is no data to show if hand articulated dental study models would show the same occlusal relationships as those determined with bite-registration wax.

Conclusion

Many researchers have attempted to devise qualitative and quantitative methods for recording malocclusion. In the earlier methods, only a few malocclusion problems were selected arbitrarily as the items to be scored. However, there was no specific definition of the various problems, or the deviations were recorded in an all-or-none manner. In the later methods, there was an increasingly obvious tendency to record items that were logically grouped. However, most of these indices were made where they could be used either directly on patients or on their dental study models, but not both. Yet those that were applicable both ways were complicated.

There was no previous study that compared measurements made using a specially designed ruler along with a mouth mirror, against a three-dimensional evaluation of the patient's traditionally trimmed orthodontic study model. Along with that, hand-articulated study models have not been compared with wax-trimmed study models.

As Vince Lombardi stated his philosophy of football:

> "There are only two or three plays a game that will determine the difference between winning and losing. I'm sorry, but I can't tell you which ones they'll be. You have to play them all 100%".

It would be beneficial to find new ways in improving and simplifying data collection during field studies and in assessing orthodontic treatment results. The PAR index, shown to be easy to use, quick, and accurate tool in the assessment of malocclusion has got its advantages over the more complicated occlusal indices, despite the fact that some of these indices were demonstrated previously intraorally and on study models, and were proven to be valid and reproducible.

STATEMENT OF THE HYPOTHESIS

The goal of this study was to compare different methods of assessing orthodontic treatment results. Specifically, direct intraoral assessment of occlusion and self administered dental impressions were compared to traditional alginate/plaster study models (thus saving time, cost of making dental study models, and allowing ease in collecting data during field studies). The following hypotheses were subjected to a paired t-test:

Null Hypothesis I: The mean intra-oral PAR score is equal to the PAR scores from the traditional orthodontic study models.

Null Hypothesis II: The mean intra-oral PAR score is equal to the PAR scores from the hand-articulated study models.

Null Hypothesis II: The mean PAR score of the hand-articulated study models is equal to the PAR scores from the traditional orthodontic study models.

MATERIALS AND METHODS

Study Sample and Design

Upon submitting the study design and research protocol to the Internal Review Board (IRB) of Case Western Reserve University and obtaining the Review Committee for Human Studies' approval, the current study was initiated (APPENDIX A). The sample size was calculated to be sixty-three subjects, derived using standard deviation values from preliminary studies involving the PAR index, with an α value set at 0.05, β at 0.20, and an effect size of 10%, in order to detect statistical significance. The subjects were orthodontically treated retention patients conveniently selected upon their return to the graduate orthodontic clinic at Case Western Reserve University for their regularly scheduled retention check-up appointments, during the period November 1998 through April 1999. After explaining to the parent and patient the procedures that were going to be added to their scheduled appointment (approximately an extra fifteen minutes) and obtaining their informed consent (APPENDICES B and C), an intraoral examination was performed on each patient, including a PAR scoring of the occlusion. Following the examination, special instructions were given to the patient on how to take an impression using a quickset impression material (President putty polyvinylsiloxane material) along with a polybite triple tray. Immediately

thereafter, a set of upper and lower traditional alginate impressions, along with a registration wax-bite, were taken by the principal investigator, which helped in articulating and trimming the models made from the alginate impressions. Other demographics, such as patient's age, date of birth, and whether or not having any temporomandibular joint dysfunction symptoms were recorded. All impressions were poured up using orthodontic plaster-stone, to later become study models. These were trimmed accordingly, then scored using the PAR index ruler.

Using the PAR index, this study was sought to compare three different methods in assessing occlusion:

Direct intraoral examination

Using polybite trays and polyvinylsiloxane impression material

Using alginate impression material and registration wax-bite

The PAR index was selected as the occlusal index of choice because of its ease to use, reproducibility, and acceptance by both patients and investigator. It also provided a single summary score for the overall alignment and occlusion (Richmond et al. 1992).

Data Collection

The primary investigator adhered to the PAR index instructions while conducting this study. He had been calibrated to use the PAR index. Using a clear and disinfected PAR plastic ruler (APPENDIX D), all of the three methods were assessed a numerical value using a clear disinfected

Each subject selected was given an identification number. Each PAR scoring data sheet included the following (APPENDICES E AND F):

name and identification number

sex

date of birth

rater's name

TMD evaluation

date of data collection

chart for intraoral PAR scores

chart for alginate impressions PAR scores

chart for polybite-polyvinylsiloxane impressions PAR scores

Polybite-Polyvinylsiloxane Impression Technique

Specific instructions were given to each subject as to the exact procedures for taking impressions of his/her own teeth. This was made easier to follow when each subject was given the "instructions for use" card dispensed by the manufacturers (APPENDIX G).

Each subject was asked to take an impression of his/her own teeth using the Coltène® President putty impression material. This is a silicone-based impression material (polyvinylsiloxane) made from a base (brown) and a catalyst (light grey), used with a rigid polybite triple tray. Each subject was asked to practice placing the tray into his/her mouth before the actual impression was taken, to become familiar with how the tray should be

oriented and seated in the mouth while biting down all the way until the upper teeth and lower teeth touched. The working time and the initial set of the material totaled about two minutes. Once the impression was set, the subject was advised to remove the impression from his/her mouth with one quick motion to minimize distortion.

After removal from the mouth, each impression was rinsed under warm running tap water, then inspected for quality by the principal investigator. If the impression was acceptable, it was sprayed liberally and left to disinfect for fifteen minutes using Citrace™ Hospital Germicidal Deodorizer (Caltech Industries, Inc., Midland, MI), then marked by the subject's identification number and wrapped in a wet napkin.

Intraoral Assessment Technique

Shortly after the completion of the polybite-polyvinylsiloxane impression procedure, an intraoral evaluation of the occlusion was performed while the patient was biting down in centric occlusion, where a PAR scoring was assessed. Using a mouth mirror, the flexible and clear PAR ruler was applied directly to measure any deviation from ideal contact point of the upper left cuspid to the upper right cuspid, along with positive overjet, overbite, and/or openbite. The other components of PAR were scored accordingly, by direct and mirror image observations, while referring to the corresponding sections on the ruler to determine their score.

Alginate Impression Technique

The third and last method used in this study was to take traditional alginate impressions of both the maxillary and mandibular dental arches, along with a registration wax-bite while the patient is biting down in centric occlusion. These impressions were taken by the principal investigator using Teflon-coated perforated orthodontic impression trays (TP Orthodontics, Inc., LaPorte, IN), Surgident® perifery wax (Heraeus Kulzer, Inc., South Bend, Indiana), and Jeltrate™ alginate impression material fast set (Caulk Dentsply International Inc., Milford, DE).

The impressions were carefully checked for accuracy, then rinsed under running tap water, disinfected using Citrace® spray, and wrapped individually with wet paper towels. A thin registration wax-bite was also taken by the principal investigator, by softening a trapezoidal piece of pink dental wax (Thompson Dental Manufacturing Company, Inc., Missoule, MT) using a gas torch. The piece of wax was then placed against the upper arch, held firmly while guiding the mandible into centric occlusion position. After waiting for about thirty seconds, the piece of wax was carefully removed from the patient's mouth, rinsed under cold water for thirty seconds, disinfected, and marked using the corresponding identification number.

Following patient's dismissal, both polybite and alginate impressions were sprayed by Delar® Surfactant (which reduces surface tension,

eliminates bubble formation, and produces sharper details) then poured-up by the principal investigator using orthodontic white stone.

While pouring up the polybite impressions, one side of the impression was filled with dental stone and allowed to set before the same could be done for the other side. A dental vibrator unit (Buffalo Dental Manufacturing, Co., Syosset, NY) was used during the pour-up to ensure the most accurate reproduction of the teeth.

All of the poured up models were allowed to set for at least thirty minutes before removal from the trays. The models were then trimmed on Pro-Trim™ orthodontic model trimmer (Whemer Co., Addison, IL). All clinical and laboratory steps were completed exclusively by the principal investigator to ensure consistency, accuracy and reliability.

The models made from the polybite impressions taken by the patients, were trimmed only to remove excess stone material, hand-articulated to the "best fit" position, and then PAR scored. The alginate impression study models, taken by the primary investigator, were trimmed with the registration wax-bite in place, allowing their backs to become parallel. They were also PAR scored. These represented the gold standard in this study because they reproducible occlusal relationships.

Each data set of the sixty-three patients included in this study required a minimum of two hours per patient to be completed, including all three methods of data collection, laboratory work time, and PAR scoring. The

Ortho Box Storage System™ (Raintree Essex, Inc., New Orleans, LA), was used to store these models.

Data Analysis

PAR Scoring

Although there has been no mention in the literature about previous studies that involved intra-oral PAR scoring, the techniques employed in this study during PAR scoring were the same as those applied on dental study models, which have been previously published (Richmond et al. 1992). All data and PAR scores were collected and scored by the primary investigator.

Statistics

All data were entered, computed and analyzed using Excel® and Microsoft Access software programs (Microsoft Excel®, Microsoft Inc., Seattle, WA). Descriptive statistics included means and standard deviations. A p-value of ≤ 0.05 was used to assign statistical significance. Statistical analysis using paired t-test for means were performed on the data collected.

Reliability

In order to define the internal reliability, three observations and PAR scoring were performed on the alginate and polybite impressions study models during the data collection process (APPENDICES G-N), with at least four-day intervals between each observation. An average of the three observations was determined for all six components of the PAR (APPENDIX O and P).

To examine the reproducibility of the intraoral PAR scoring, another calibrated investigator was asked to evaluate thirty conveniently selected patients. Each patient received an intraoral evaluation and PAR score assessment by both investigators (APPENDICES Q AND R).

RESULTS

Total Sample and Demographics

The total sample (N = 63) included conveniently selected orthodontically treated patients. Thirty-two percent were male and 68% female. The average age was 16.4 years. Seventeen percent of the patients reported TMD symptoms (18% male, 82% female).

PAR Score

The intraoral versus alginate PAR scores are reported in Table 1. Each of the six components is listed with their respective mean scores as follows:

TABLE 1. -- Intraoral versus alginate impressions PAR score (N = 63)

Parameter	Intraoral Mean & Std Dv	Alginate Mean & Std Dv	p-value
TOTAL	8.2 ± 4.5	9.1 ± 4.7	0.003*
UAS	1.0 ± 1.2	1.1 ± 1.1	0.700
RBO	2.4 ± 1.5	2.5 ± 1.5	0.129
LBO	2.5 ± 1.5	2.9 ± 1.6	0.009*
OJ	0.6 ± 1.7	0.8 ± 1.9	0.083
OB	1.4 ± 1.6	1.5 ± 1.6	0.419
CNT	0.2 ± 0.9	0.2 ± 0.9	0.321

*statistically significant $p \leq 0.05$

As found in Table 1, PAR scores between intraoral and alginate impressions are significant between the total PAR score ($p = 0.003$) and the left buccal occlusion component ($p = 0.009$). A trend toward significance is noted between the overjet components ($p = 0.083$).

The intraoral versus polybite-polyvinysiloxane PAR scores are reported in Table 2 as follows:

TABLE 2. -- Intraoral versus polybite-polyvinylsiloxane impressions PAR score (N = 63)

Parameter	Intraoral Mean & Std Dv	Polybite-Polyvinyl Mean & Std Dv	p-value
TOTAL	8.2 ± 4.5	8.3 ± 4.6	0.620
UAS	1.0 ± 1.2	1.1 ± 1.1	0.163
RBO	2.4 ± 1.5	2.4 ± 1.6	0.863
LBO	2.5 ± 1.5	2.6 ± 1.5	0.340
OJ	0.6 ± 1.7	0.6 ± 1.6	1.000
OB	1.4 ± 1.6	1.4 ± 1.6	0.766
CNT	0.2 ± 0.9	0.1 ± 0.7	0.083

PAR scores between the intraoral and polybite impressions do not show any significant differences, except for the centerline component which shows a trend toward significance ($p = 0.083$).

The alginate versus polybite-polyvinylsiloxane impressions PAR scores are reported in Table 3.

TABLE 3. -- Alginate versus polybite-polyvinylsiloxane impressions PAR score (N = 63)

Parameter	Alginate Mean & Std Dv	Polybite-Polyvinyl Mean & Std Dv	p-value
TOTAL	9.1 ± 4.7	8.3 ± 4.6	0.083
UAS	1.1 ± 1.1	1.1 ± 1.1	0.443
RBO	2.5 ± 1.5	2.4 ± 1.6	0.398
LBO	2.9 ± 1.6	2.6 ± 1.5	0.083
OJ	0.8 ± 1.9	0.6 ± 1.6	0.260
OB	1.5 ± 1.6	1.4 ± 1.6	0.742
CNT	0.2 ± 0.9	0.1 ± 0.7	0.159

PAR scores show a trend toward significance between the total alginate and polybite-polyvinylsiloxane impressions scores along with the left buccal occlusion component ($p = 0.083$).

Reliability of Intraoral PAR Scoring

To test the reliability of the intra-oral PAR measurements, another calibrated examiner evaluated thirty conveniently selected patients. Both the initial investigator and second examiner scored these thirty patients independently, as shown in Table 4.

TABLE 4.-- Intraoral PAR scoring between primary investigator and second examiner (N = 30)

Parameter	1st examiner Intraoral PAR Mean & Std Dv	2nd Examiner Intraoral PAR Mean & Std Dv	p-value
TOTAL	8.0 ± 4.8	7.6 ± 4.9	0.309
UAS	1.3 ± 1.4	1.3 ± 1.4	0.326
RBO	2.2 ± 1.6	2.4 ± 2.1	0.415
LBO	2.5 ± 1.9	2.2 ± 1.9	0.169
OJ	0.8 ± 1.9	0.7 ± 1.7	0.327
OB	0.9 ± 1.4	0.9 ± 1.4	0.921
CNT	0.2 ± 0.7	0.2 ± 0.7	1.000

Intraoral PAR scores between the primary investigator and second examiner show reliability of the intraoral PAR scoring method. There were no significant differences between any of the six components that make up the PAR index.

DISCUSSION

In the recent years, there has been an increased awareness by the general public for need of orthodontic treatment along with an interest by third party payers with regard to the efficacy of orthodontics in straightening teeth. One has to find a quick and valid way for evaluating malocclusion. Traditional orthodontic study models, usually made from alginate impressions, provide a three-dimensional representation of the patient's occlusion and have been essential records for an orthodontic patient's evaluation during diagnosis, treatment planning, and follow-up. They are required from a medico-legal point of view and more or less acceptable by both patients and clinicians. However, they have a number of disadvantages. They are brittle, relatively bulky, and require considerable storage space when large numbers of patients are treated. Given these limitations, it was necessary to investigate some other methods for recording malocclusion. One such method is a direct intraoral assessment, and/or the use of less bulky and time consuming study models. In this study, the PAR index (Richmond et al. 1992) was used to measure the validity of three different methods in assessing the occlusion of sixty-three orthodontically treated patients.

Occlusal Assessment

The results of this study indicate that the intraoral assessment of occlusion underestimates the actual three-dimensional occlusal relationships, as measured by the PAR index (mean intraoral total PAR score was 8.2 $\pm$ 4.5, versus alginate impressions total PAR score 9.1 $\pm$ 4.7, with $p = 0.003$). One of the difficulties encountered using the PAR ruler is the fact that the posterior buccal segments are much more difficult to evaluate intraorally than on study models. Indirect vision, using a mouth mirror, is the only way to evaluate the latter segments while PAR scoring them. The regular mouth mirror is not large enough to view the molar areas in great details especially when looking at the second molars. An accurate assessment is almost never possible compared to study models. This is due to their further posterior position in the mouth with poor visualization and illumination, which could be attributed to the effect of the cheeks interfering with a clear assessment.

Although the PAR ruler is a flexible and clear tool, using it while measuring the upper anterior segment alignment was a time consuming and difficult task. It was difficult holding it antero-posteriorly and/or transversely because of its interference with either the soft tissue or tooth structures. A modification to the ruler is necessary for proper assessment of this area. The PAR index criteria will remain the same, but that section of the ruler will have

to be oriented differently to accommodate the examiner while performing the measurements.

In measuring the overbite, it was necessary, at times, to mark the crowns of the teeth, which was not acceptable to the patient. To circumvent this problem, the examiner can incorporate a millimeter probe, so that he/she can compare the amount of overbite and/or openbite to its corresponding section on the PAR ruler. This may seem a lengthy procedure, but it is more hygienic and accurate.

The fact that the principal investigator was right-handed might explain the significant difference in PAR score noted between the intraoral and alginate impressions left buccal occlusion (intraoral 2.5 $\pm$ 1.5, alginate 2.9 $\pm$ 1.6, with $p = 0.009$).

While comparing intraoral and polybite-polyvinylsiloxane impressions methods, there was a trend toward significance at the centerline component ($p = 0.083$). This could be the result of poorly defined midlines on the study casts, since many of the polybite impressions had "dual bite" effect in the anterior region. However, the PAR ruler did not seem sensitive enough to measure any difference between both methods at the upper anterior segment, overjet, and overbite components. The inability to clearly evaluate the second molars occlusion intraorally is similar to not capturing them in most of the polybite-polyvinylsiloxane impressions. This could be contributed to the fact that the polybite trays did not extend far enough posteriorly on

some patients, and/or were seated more anteriorly than they were supposed. In either case, the PAR score at the buccal segment areas was not affected by such errors.

The use of alginate material to take impressions that do become orthodontic study models has been the traditional way in modern orthodontics. These, along with the registration wax-bite taken while the patient is occluding in centric occlusion, reproduce the intraoral relationship of teeth in a three dimensional manner. Since the PAR index was originally developed and validated using study models made from alginate impressions, it mandated considering them as the gold standard in this study. In trimming the study models made from these impressions with the registration wax-bite in place, their backs were made parallel, allowing for consistency during the data collection process. The results of this study show that there were statistical differences between the total PAR score of the alginate versus intra-oral assessments (alginate 9.1 $\pm$ 4.7, intraoral 8.2 $\pm$ 4.5), with a trend toward significance between the alginate and polybite-polyvinylsiloxane assessments (polybite-polyvinylsiloxane 8.3 $\pm$ 4.6, $p = 0.083$). Looking at each of the components individually, the PAR scores were either the same or higher for the alginate impressions than the polybite-polyvinylsiloxane and intraoral methods. The overjet component between the intraoral and alginate impressions method shows a trend toward significance

($p = 0.083$). This could be attributed to the fact that "hand-articulated" study models are not scored in consistently repeatable positions.

The polybite-polyvinylsiloxane impression system allows the patient to take his/her own impression, based solely on given instructions. This is a quick way in taking impressions that will be made into study models. Although these are not state-of-the-art models or a totally accurate representation of the teeth, they allow for a practical assessment of occlusion during field studies data collection and in evaluating treatment progress. They compare to traditional study models by the fact that they are a three dimensional representation of the occlusion. The results from this study showed that the PAR scores from the "hand-articulated" study models to be similar to those collected from the intraoral assessment, except for the centerline component ($p = 0.083$). When compared to alginate impressions study models, this method demonstrated a trend toward significance ($p = 0.083$) in the total PAR score and in the left buccal occlusion component. Therefore, the polybite-polyvinylsiloxane impressions study models are useful for a quick assessment of occlusion, but do not represent, with full accuracy, the truth of the matter.

In determining the reliability of the intraoral PAR scoring method, there were no significant differences between two examiners who evaluated thirty patients, indicating that the method was reliable.

While conducting surveys, it may be acceptable to use the intraoral assessment method, for a quick determination of occlusion. This is true also for a clinical evaluation of a patient. However, this method should never be considered as the determinant of the malocclusion status, but as a simple, inexpensive, and easy to use method of assessment.

During field studies, the polybite-polyvinylsiloxane impressions are preferred over the intraoral assessment, since the latter showed more variation from the gold standards. This may be a costly and lengthy procedure, but will generate study models that are useful at anytime. Another advantage of these impressions is for post-orthodontic treatment evaluation of patients who have moved away from the area where their treatment was rendered. This will allow reaching all those patients needed in treatment stability studies. Although the polybite-polyvinylsiloxane impressions may not be an accurate representation of the fully erupted dentition, they can mimic the occlusion captured by alginate impressions. If registration wax-bites are taken simultaneously with these impressions, a much better set of study models can be generated. They can be useful in evaluating orthodontic treatment status of patients approaching the completion of their treatment. The polybite impressions will allow for a three dimensional evaluation of the patients' dentition, thus making it easier on the clinician to carefully inspect the position of the teeth before removing the braces. Their drawbacks though

will remain the distortions due to manipulation errors by the patients, and/or not capturing the most posterior molars in full.

Therefore, although alginate impressions are more costly and time consuming, they remain the more accurate representation of the patient's occlusion than an intraoral assessment or a less expensive method of taking impressions.

Limitations of the Study

This study included sixty-three conveniently selected retention patients. However, the procedures involved during the data collection were time consuming and dependent on various factors. Not only, did the principal investigator carefully explain to each patient and parent the procedures involved before getting their informed consent, but he also had to deal with some turndowns. Other patients were not included in this study because the principal investigator was not available at the time where they presented to the clinic. For the most, he had to fit them into his daily patients' schedule, as they showed up to see him or other clinicians at the graduate orthodontic clinic at Case Western Reserve University for their scheduled fifteen minute appointments, and agreed to undergo the procedures that were involved. The fact that these patients were conveniently selected and have received comprehensive orthodontic treatment over limited treatment may have introduced selection bias into the study.

It must be acknowledged that the PAR index measures the patient's dental alignment and occlusion, and it is not designed to measure what may be regarded as the various ultimate outcomes of orthodontic treatment, such as improved appearance and social-psychological well-being or reduced susceptibility to oral disease or dysfunction.

There were limitations in the direct assessment of the occlusion. Intra-oral PAR scoring has never been used prior to this study and in some instances was difficult to assess. The fact that the PAR ruler was designed for study models' assessment made it hard to measure the upper anterior segment alignment and the posterior buccal segments intraorally. The assessment was based on a mirror image reflection and not direct vision.

Although most impressions obtained were suitable for PAR scoring, a number of the polybite-polyvinylsiloxane impressions were distorted due to manipulation errors by the patients. First, by not biting down all the way and keeping the teeth together until the material was fully set. Second by biting down more than once through the same impression leading to a "dual-tooth" appearance effect especially at the incisors' region. And third because the impression trays may not have been loaded properly by the patients. In many instances, the fact that the standard polybite trays were not extended far enough posteriorly did not allow for proper and/or complete imprints of the second molars in the impressions. Some of these trays had rough and sharp borders that led to patients' discomfort while he or she was trying to seat the

impression trays, thus adding more distortion to the impressions. Although the PAR index is reliable in measuring contact point displacement, amount of overjet and overbite, and midline deviation, it may not be sensitive enough to measure minute deviations in the buccal segments that are caused by the different methods in handling and articulating the polybite-polyvinylsiloxane study models.

Although the measurements were collected by the principal investigator at different time intervals, he was never blinded during the alginate and polybite-polyvinylsiloxane impressions' study models scoring. The fact that the measurements were take each time off the same study models may have introduced bias into the study. One can become familiar with these study models and unwillingly score them similarly to the previous time. This is more likely for the alginate impressions study models than for the hand-articulated ones, since the latter may or may not be in the same occlusion at each observation.

Future studies should evaluate if variation in polybite tray sizes will allow for improved impressions taken by the patients. The self-taking impression method, using the polybite trays, should also be examined on a population sample that has never been exposed to impressions but was instructed on how to do the procedure. Post-orthodontic occlusal adjustment may be helpful in obtaining "hand-articulated" study models that resemble registration wax-bite articulated ones. Temporomandibular joint disorder

should be evaluated as a possible contributor to the discrepancy in occlusion. The intraoral PAR assessment method may be used to evaluate the occlusion of patients who are still in treatment, in order to determine their orthodontic treatment status in a quick and reasonably accurate manner.

SUMMARY AND CONCLUSIONS

Three different methods of assessing occlusion were compared in a sample of sixty-three conveniently selected retention patients. Polybite-polyvinylsiloxane impressions, followed by an intraoral assessment of occlusion, then a set of alginate impressions were assigned a PAR score. The data collected was analyzed using descriptive statistics and paired t-test, and the following were concluded from this study:

1. Over two third (68%) of the patient sample were females.
2. Temporomandibular dysfunction symptoms were reported in 17% of the patients (18% male, 82% female).
3. Statistical differences were noted between the total intra-oral versus alginate impression PAR score and left buccal occlusion ($p < 0.05$).
4. Trends toward significance were noted at the overjet component between the intraoral and alginate impressions, the centerline component between the intraoral and polybite-polyvinylsiloxane impressions, and the left buccal occlusion and total PAR score between the alginate and polybite-polyvinylsiloxane impressions ($p = 0.083$).
5. Right-handed examiners underestimate the intraoral left buccal occlusion ($p = 0.009$).
6. Intra-oral assessment of occlusion resembles "hand-articulated" study models, where both methods were shown to underscore the actual occlusion.

7. Some modifications to the current PAR ruler would allow for easier intraoral assessment of the upper anterior segment and overbite components.

8. While taking polybite impressions, using proper tray size, along with proper loading and handling of the impression material, and obtaining registration wax-bite will lead to more accurate and valuable study models.

APPENDIX A. -- Approval of the University Review Committee on Human Studies

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

TO: **Hans, Mark G.**
Feghali, Roland

Dept/School: **Dentistry**

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

The committee has reviewed and approved your proposal entitled: **Comparing Intraoral Clinical Observation with Study Model Assessment of Occlusion using the P.A.R. I**

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 **12/30/1999**

SIGNED FOR THE COMMITTEE BY:

Approval Date:
1/13/1999

Christian L. LaMantia
Associate Director
Office of Research Administration

CZ

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

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

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

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

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

APPENDIX B. -- Informed consent form for minor participant

INFORMED CONSENT TO PARTICIPATE IN RESEARCH
(Minor)

Project title: **Comparing Intra-oral Clinical Observation with Study Model Assessment of Occlusion using the P.A.R. Index.**

I, the parent or guardian of _____ (subject), a minor ____ years of age consent to his/her participation in a program of research being conducted by Dr. Roland L. Feghali.

I understand that there are no foreseeable risks expected in this study beyond routine dental examination, which does involve oral examination of the teeth, taking alginate impressions and wax bites, and asking him/her to take his/her own dental impressions.

I understand that _____ (subject) will not benefit from this study directly. However, over a period of time he/she will be informed how the results drawn from the data collected will help him/her and many others in dealing with the issue of how and when dental impressions should be taken, and their accuracy in reproducing how the teeth actually come together when one bites down. _____ (subject) has to be compliant to instructions given to him/her by the orthodontist on how long to wear the retainers and how to take care of his/her teeth.

I should report any injury or illness I believe to be related to this research project to Dr. Roland L Feghali (Principal Investigator) at 216-368-6758 or the chairperson of the Case Western Reserve University Department of Orthodontics Dr. Mark Hans at 216-368-4649.

I understand that all data obtained during the course of the study will be kept confidential and accessible only to the principal investigator and his assistants on the project. Should the results of the present study be published, _____ (subject) will be referred to only by a number.

Any questions that I may have involving this research and my rights may be addressed to Dr. Roland L Feghali at 216-368-6758 or the Chairperson at the Case Western Reserve University Department of Orthodontics, Dr. Mark Hans at 216-368-4649.

I acknowledge that Dr. Roland L. Feghali has fully explained to me the risks involved and the need for the research; has informed me that I may withdraw my child from participation at any time without prejudice; and has offered to answer any inquiries which I may make concerning the procedures to be followed.

I freely and voluntarily consent to my child's participation in the research project.

_____ _____
Signature of Parent/Guardian Date

_____ _____
Signature of Principal Investigator Date

APPENDIX C. -- Informed consent form for adult participant

INFORMED CONSENT TO PARTICIPATE IN RESEARCH
(Adult)

Project title: **Comparing Intraoral Clinical Observation with Study Model Assessment of Occlusion using the P.A.R. Index.**

I, _____(subject), state that I am over 18 years of age and that I wish to participate in a program of research being conducted by Dr. Roland L. Feghali.

I understand that there are no foreseeable risks expected in this study beyond routine dental examination, which does involve oral examination of my teeth, taking alginate impressions and wax bites, and asking me to take my own dental impressions.

I understand that I will not benefit from this study directly. However, over a period of time I will be informed how the results drawn from the data collected will help me and many others in dealing with the issue of how and when dental impressions should be taken, and their accuracy in reproducing how my teeth actually come together when I bite down. I have to be compliant to instructions given to me by my orthodontist on how long to wear my retainers and how to take care of my teeth.

I should report any injury or illness I believe to be related to this research project to Dr. Roland L Feghali (Principal Investigator) at 216-368-6758 or the chairperson of the Case Western Reserve University Department of Orthodontics Dr. Mark Hans at 216-368-4649.

I understand that all data obtained during the course of the study will be kept confidential and accessible only to the principal investigator and his assistants on the project. Should the results of the present study be published, I will be referred to only by a number.

My participation in the study is voluntary and I am free to withdraw at any time without penalty or loss of benefits that I am otherwise entitled to. I will be given a copy of this form to keep.

Any questions that I may have involving this research and my rights may be addressed to Dr. Roland L Feghali at 216-368-6758 or the Chairperson at the Case Western Reserve University Department of Orthodontics, Dr. Mark Hans at 216-368-4649.

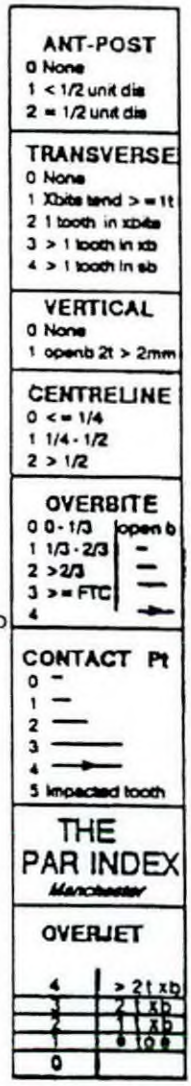
I acknowledge that Dr. Roland L. Feghali has fully explained to me the risks involved and the need for the research; has informed me that I may withdraw from participation at any time without prejudice; and has offered to answer any inquiries which I may make concerning the procedures to be followed.

I freely and voluntarily consent to my participation in the research project.

_____ _____
Signature of Participant Date

_____ _____
Signature of Principal Investigator Date

APPENDIX D. -- The PAR ruler



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

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

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

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

ABBREVIATIONS

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

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

APPENDIX E.--The PAR scoring sheet

Patient _____ Rater _____ Date _____

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

APPENDIX F.-- Patient demographic information data sheet

TABLE 5. -- Patient demographic information data sheet

Identification	Gender	DOB	Recall	Age	TMD
1	F	6/18/82	11/10/98	16.4	Y
2	F	2/26/85	11/17/98	13.7	N
3	M	8/13/83	11/17/98	15.3	N
4	F	8/11/78	11/10/98	20.2	Y
5	F	5/11/84	11/11/98	14.5	N
6	F	6/19/86	11/12/98	12.4	N
7	F	7/14/84	11/13/98	14.3	N
8	F	10/19/85	11/18/98	13.1	N
9	F	7/6/82	11/20/98	16.4	Y
10	F	11/1/82	11/20/98	16.1	N
11	M	2/3/85	11/23/98	13.8	N
12	F	3/9/85	11/23/98	13.7	N
13	F	11/8/77	11/24/98	21.0	N
14	M	3/4/84	11/30/98	14.7	N
15	M	2/27/81	12/1/98	17.8	N
16	M	5/22/85	12/1/98	13.5	N
17	F	10/18/83	12/2/98	15.1	N
18	F	10/23/84	12/3/98	14.1	N
19	M	12/4/85	12/4/98	13.0	N
20	F	8/19/78	12/7/98	20.3	Y
21	M	2/25/70	12/7/98	28.8	N
22	F	8/22/80	12/7/98	18.3	Y
23	M	6/5/85	12/8/98	13.5	N
24	M	1/4/83	12/10/98	15.9	N
25	M	11/1/81	12/14/98	17.1	N
26	M	3/3/84	12/14/98	14.8	Y
27	F	2/21/82	12/14/98	16.8	N
28	F	3/8/84	12/15/98	14.8	N
29	F	4/16/84	12/15/98	14.7	Y
30	F	4/24/84	1/7/99	14.7	N
31	M	10/6/79	1/7/99	19.3	N
32	F	1/27/75	1/14/99	24.0	N
33	M	4/17/83	1/14/99	15.7	N

TABLE 5. -- Patient demographic information data sheet (Continued)

Identification	Gender	DOB	Recall	Age	TMD
34	M	7/11/79	1/19/99	19.5	N
35	F	8/26/82	1/21/99	16.4	N
36	M	2/16/78	1/26/99	20.9	N
37	M	2/9/75	4/8/99	24.2	Y
38	M	5/10/81	1/27/99	17.7	N
39	F	1/10/77	1/28/99	22.1	N
40	F	2/17/83	2/2/99	16.0	N
41	F	1/3/82	2/2/99	17.1	Y
42	M	2/21/83	2/2/99	15.9	N
43	F	2/25/83	2/3/99	15.9	N
44	M	1/28/78	2/3/99	21.0	N
45	F	2/22/78	2/5/99	21.0	N
46	F	12/26/81	2/8/99	17.1	N
47	F	2/27/81	2/9/99	18.0	N
48	F	4/30/84	2/10/99	14.8	N
49	F	12/1/83	2/11/99	15.2	N
50	F	3/31/82	2/11/99	16.9	N
51	M	4/15/82	2/17/99	16.8	N
52	F	7/21/49	2/22/99	49.6	N
53	F	2/26/85	2/22/99	14.0	N
54	F	11/8/83	2/22/99	15.3	N
55	F	12/1/83	2/25/99	15.2	N
56	F	8/10/78	3/8/99	20.6	N
57	F	12/15/84	3/9/99	14.2	N
58	F	3/14/82	3/15/99	17.0	N
59	F	10/9/81	3/16/99	17.4	N
60	F	6/7/78	3/18/99	20.8	Y
61	F	1/2/52	3/19/99	47.2	Y
62	F	1/20/88	3/25/99	11.2	N
63	F	3/17/80	3/30/99	19.0	N

APPENDIX G.--Polybite impression technique patient instruction card

coltène®
PRESIDENT putty soft

1- Scoop out base and catalyst 1:1



2- Mix the putty material



3- Load in the polybite triple tray



APPENDIX H. -- PAR data for the intraoral measurements

TABLE 6. -- PAR data for the intraoral measurements

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
2	0	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
3	1	1	0	0	2	0	0	0	0	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
6	5	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
7	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
8	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	1	3
10	0	2	0	0	4	1	0	0	2	0	0	0	0	1	3	0	0
11	0	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
12	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
14	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
15	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
16	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
18	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
19	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
20	2	1	0	0	2	1	0	0	2	1	0	5	2	0	6	2	6
21	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
22	3	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
23	1	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
24	1	1	0	1	4	1	0	0	2	0	1	5	0	1	3	0	0
25	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
27	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	0	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
33	0	2	0	0	4	1	0	0	2	0	1	5	1	0	3	0	0

TABLE 6. -- PAR data for the intraoral measurements (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	1	6	0	0	0	0	0	0	0	0
35	0	1	0	0	2	0	0	0	0	0	0	0	1	0	3	1	3
36	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
39	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
40	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
41	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
42	2	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
45	2	1	0	0	2	0	0	0	0	0	0	0	1	0	3	0	0
46	0	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
47	1	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
49	1	2	0	0	4	2	0	0	4	0	1	5	0	1	3	0	0
50	2	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
51	4	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	0	0	0	0	0	0	0	1	0	3	1	3
53	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
54	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	2	0	1	6	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
58	1	1	0	0	2	2	0	0	4	1	0	5	0	0	0	0	0
59	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
60	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
61	3	1	0	0	2	0	0	0	0	0	0	0	1	0	3	0	0
62	1	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	0
63	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX I. -- PAR data from the first set of measurements of the alginate impression study models

TABLE 7. -- PAR data from the first set of measurements of the alginate impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
3	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
6	5	1	0	1	4	2	0	0	4	0	0	0	1	0	3	0	0
7	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
8	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	1	3
10	0	2	0	1	6	1	0	0	2	0	0	0	0	1	3	0	0
11	1	1	0	0	2	2	0	1	6	0	0	0	0	0	0	0	0
12	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	1	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
15	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
16	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
18	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
19	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
20	1	1	0	0	2	1	0	0	2	1	0	5	2	0	6	2	6
21	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
22	3	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
23	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
24	1	1	0	1	4	2	0	1	6	0	1	5	0	1	3	0	0
25	1	2	0	1	6	1	0	2	6	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	1	4	0	0	0	1	0	3	0	0
33	1	2	0	0	4	2	0	0	4	0	1	5	0	0	0	0	0

TABLE 7. -- PAR data from the first set of measurements of the alginate impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	1	6	0	0	0	0	1	3	0	0
35	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	1	3
36	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
41	1	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
42	2	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
45	2	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
46	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
47	1	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
49	1	1	0	1	4	1	0	0	2	0	1	5	0	1	3	0	0
50	2	1	0	0	2	1	0	1	4	0	0	0	0	1	3	0	0
51	4	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
54	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	1	1	0	1	4	2	0	0	4	1	0	5	0	0	0	0	0
59	3	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
60	0	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	1	0	0	2	1	0	1	4	0	0	0	0	1	3	0	0
63	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX J. -- PAR data from the first set of measurments of the polybite-polyvinylsiloxane impression study models

TABLE 8. -- PAR data from the fisrt set of measurements of the polybite-polyvinylsiloxane impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
3	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
6	5	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
7	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
10	2	2	0	0	4	1	0	0	2	0	0	0	0	2	6	0	0
11	1	2	0	1	6	2	0	1	6	0	0	0	0	0	0	0	0
12	1	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	0	1	0	0	2	1	0	1	4	0	0	0	1	0	3	0	0
15	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
16	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
17	2	2	0	0	4	0	0	0	0	0	0	0	1	0	3	0	0
18	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
19	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
20	0	2	0	0	4	2	0	1	6	1	0	5	1	0	3	2	6
21	0	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
22	3	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
23	1	1	0	0	2	1	0	0	2	1	0	5	0	0	0	0	0
24	1	1	0	2	6	1	0	1	4	0	0	0	0	0	0	0	0
25	2	2	0	1	6	1	0	0	2	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	0	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
31	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
33	1	1	0	0	2	2	0	0	4	0	1	5	0	1	3	0	0

TABLE 8. -- PAR data from the fisrt set of measurements of the polybite-polyvinylsiloxane impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
35	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
36	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
41	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
42	2	1	0	0	2	2	0	0	4	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
45	2	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
46	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
47	1	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
49	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
50	2	1	0	0	2	2	0	1	6	0	0	0	0	1	3	0	0
51	3	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
54	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
59	3	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
60	0	0	0	1	2	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	2	0	0	4	1	0	0	2	0	0	0	0	1	3	0	0
63	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX K. -- PAR data from the second set of measurements of the alginate impression study models

TABLE 9. -- PAR data from the second set of measurements of the alginate impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
3	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
6	4	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
7	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
8	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	1	3
10	0	2	0	1	6	1	0	0	2	0	0	0	0	1	3	0	0
11	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	0
12	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	0	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
15	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
16	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
18	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
19	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
20	1	1	0	0	2	1	0	0	2	1	0	5	2	0	6	2	6
21	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
22	3	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
23	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
24	1	1	0	1	4	2	0	1	6	0	1	5	0	1	3	0	0
25	1	1	0	1	4	1	0	2	6	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	1	4	0	0	0	1	0	3	0	0
33	1	2	0	0	4	2	0	0	4	0	1	5	0	0	0	0	0

TABLE 9. -- PAR data from the second set of measurements of the alginate impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	1	6	0	0	0	0	1	3	0	0
35	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	1	3
36	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
41	1	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
42	1	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
45	2	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
46	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
47	1	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
49	1	1	0	1	4	1	0	0	2	0	0	0	0	1	3	0	0
50	2	1	0	0	2	1	0	1	4	0	0	0	0	1	3	0	0
51	4	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
54	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	1	1	0	1	4	2	0	0	4	1	0	5	0	0	0	0	0
59	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
60	0	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	2	0	0	4	1	0	1	4	0	0	0	0	1	3	0	0
63	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX L. -- PAR data from the second set of measurements of the polybite-polyvinylsiloxane impression study models

TABLE 10. -- PAR data from the second set of measurements of the polybite-polyvinylsiloxane impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
3	1	1	0	0	2	0	0	0	0	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
6	5	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
7	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	3
10	2	2	0	1	6	1	0	0	2	0	0	0	0	1	3	0	0
11	1	2	0	1	6	2	0	1	6	0	0	0	0	0	0	0	0
12	1	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	0	1	0	0	2	1	0	1	4	1	0	5	1	0	3	0	0
15	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
16	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
18	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
19	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
20	0	2	0	0	4	2	0	1	6	1	0	5	2	0	6	2	6
21	0	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
22	3	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
23	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
24	1	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
25	2	2	0	1	6	1	0	0	2	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	0	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
33	1	1	0	0	2	2	0	0	4	0	1	5	0	1	3	0	0

TABLE 10. -- PAR data from the second set of measurements of the polybite-polyvinylsiloxane impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
35	0	1	0	0	2	0	0	0	0	0	0	0	1	0	3	0	0
36	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	0	0	1	2	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
41	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
42	2	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
45	2	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
46	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
47	1	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
49	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
50	2	2	0	0	4	1	0	1	4	0	0	0	0	1	3	0	0
51	4	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
54	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
59	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
60	0	0	0	1	2	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	0
63	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX M. -- PAR data from the third set of measurements of the alginate impression study models

TABLE 11. -- PAR data from the third set of measurements of the alginate impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
3	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
6	3	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
7	0	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
8	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	1	0	0	2	1	0	5	1	0	3	1	3
10	0	1	0	1	4	1	0	0	2	0	0	0	0	1	3	0	0
11	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	0
12	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	0	1	0	0	2	1	0	0	2	1	0	5	1	0	3	0	0
15	0	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
16	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
18	2	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
19	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
20	1	1	0	0	2	1	0	0	2	1	0	5	2	0	6	2	6
21	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
22	4	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
23	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
24	1	2	0	1	6	2	0	1	6	0	1	5	0	1	3	0	0
25	1	1	0	1	4	1	0	2	6	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	1	2	0	0	4	2	0	1	6	0	0	0	0	0	0	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	1	4	0	0	0	1	0	3	0	0
33	1	1	0	0	2	2	0	0	4	0	1	5	0	0	0	0	0

TABLE 11. -- PAR data from the third set of measurements of the alginate impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	1	6	0	0	0	0	1	3	0	0
35	1	1	0	0	2	1	0	0	2	0	0	0	1	0	3	1	3
36	1	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
38	1	2	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
41	1	0	0	0	0	1	0	0	2	1	0	5	1	0	3	0	0
42	1	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	0
45	3	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
46	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
47	1	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
49	1	1	0	1	4	1	0	0	2	0	0	0	0	1	3	0	0
50	1	1	0	0	2	1	0	1	4	0	0	0	0	1	3	0	0
51	3	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
54	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	2	1	0	1	4	2	0	0	4	1	0	5	0	0	0	0	0
59	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
60	0	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	2	0	0	4	1	0	1	4	0	0	0	0	1	3	0	0
63	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX N. -- PAR data from the third set of measurements of the polybite-polyvinylsiloxane impression study models

TABLE 12. -- PAR data from the third set of measurements of the polybite-polyvinylsiloxane impression study models

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
1	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
2	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
3	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
4	2	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
5	0	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
6	5	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
7	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	1	3
10	2	2	0	1	6	1	0	0	2	0	0	0	1	1	6	0	0
11	1	2	0	1	6	2	0	1	6	0	0	0	0	0	0	0	0
12	1	0	0	0	0	1	0	0	2	0	0	0	1	0	3	0	0
13	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
14	0	1	0	0	2	1	0	1	4	1	0	5	1	0	3	0	0
15	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
16	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	0
17	2	2	0	0	4	1	0	0	2	0	0	0	1	0	3	0	0
18	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	0
19	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
20	0	2	0	0	4	2	0	1	6	1	0	5	1	0	3	2	6
21	0	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
22	3	1	0	0	2	2	0	0	4	0	0	0	1	0	3	0	0
23	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
24	1	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	0
25	2	2	0	1	6	1	0	0	2	0	0	0	0	0	0	0	0
26	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
27	1	1	0	0	2	1	0	0	2	0	1	5	0	0	0	0	0
28	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
29	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
30	0	1	0	0	2	1	0	1	4	0	0	0	1	0	3	0	0
31	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
32	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
33	1	1	0	0	2	2	0	0	4	0	1	5	0	1	3	0	0

TABLE 12. -- PAR data from the third set of measurments of the polybite-polyvinylsiloxane impression study models (Continued)

ID	UAS	RBO-AP	RBO-V	RBO-Trans	RBO	LBO-AP	LBO-V	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	cnt	CNT
34	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
35	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	3
36	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	1	1	0	1	4	0	0	1	2	0	0	0	0	0	0	0	0
39	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
40	0	2	0	0	4	2	0	0	4	0	0	0	1	0	3	0	0
41	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
42	2	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	0
43	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
44	2	2	0	0	4	2	0	0	4	1	0	5	1	0	3	0	0
45	2	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	0
46	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	0
47	1	0	0	0	0	2	0	0	4	0	0	0	1	0	3	0	0
48	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
49	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
50	2	2	0	0	4	1	0	1	4	0	0	0	0	1	3	0	0
51	4	1	0	0	2	2	0	0	4	1	0	5	1	0	3	0	0
52	2	1	0	1	4	1	0	0	2	0	0	0	1	0	3	0	0
53	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
54	0	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	0
55	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
56	1	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
57	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
58	1	1	0	1	4	2	0	0	4	0	0	0	0	0	0	0	0
59	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0
60	0	0	0	1	2	1	0	1	4	0	0	0	0	0	0	0	0
61	2	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
62	1	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	0
63	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	0

APPENDIX O.--Average PAR scores from the alginate impressions study models three observations

TABLE 13.-- Average PAR scores from the alginate impressions study models three observations

ID	UAS	RBO	LBO	OJ	OB	CNT	TOTAL
1	2	4	4	5	3	0	18
2	1	4	4	0	0	0	9
3	1	2	2	0	3	0	8
4	2	4	4	0	3	0	13
5	0	2	4	0	3	0	6
6	5	4	4	0	3	0	16
7	0	4	4	0	0	0	8
8	2	2	0	0	0	0	4
9	2	4	4	5	3	3	21
10	0	6	2	0	3	0	11
11	1	2	6	0	0	0	9
12	0	2	2	0	3	0	7
13	2	2	2	0	0	0	6
14	1	2	2	5	3	0	13
15	0	2	2	0	0	0	4
16	0	2	4	0	0	0	6
17	2	4	4	0	3	0	13
18	2	4	4	0	0	0	10
19	0	2	0	0	0	0	2
20	1	2	2	5	6	6	22
21	0	0	4	0	0	0	4
22	3	0	4	0	3	0	10
23	1	2	2	0	0	0	5
24	1	4	6	5	3	0	19
25	1	6	6	0	0	0	13
26	0	4	4	0	3	0	11
27	1	2	2	5	0	0	10
28	1	2	2	0	0	0	5
29	3	2	2	0	0	0	7
30	1	4	6	0	0	0	11
31	0	4	4	0	3	0	11
32	0	2	4	0	3	0	9
33	1	4	4	5	0	0	14

TABLE 13.-- Average PAR scores from the alginate impressions study models three observations (Continued)

ID	UAS	RBO	LBO	OJ	OB	CNT	TOTAL
34	0	0	6	0	3	0	9
35	1	2	2	0	3	3	11
36	0	4	4	0	3	0	11
37	1	2	0	0	0	0	3
38	1	4	0	0	0	0	5
39	0	2	2	0	0	0	4
40	0	4	4	0	3	0	11
41	1	2	2	5	3	0	13
42	2	0	2	0	3	0	7
43	1	0	2	0	0	0	3
44	1	4	4	0	0	0	9
45	2	0	2	0	3	0	7
46	1	0	2	0	0	0	3
47	1	2	4	0	3	0	10
48	1	4	0	0	0	0	5
49	1	4	2	5	3	0	15
50	2	2	4	0	3	0	11
51	4	2	4	5	3	0	18
52	2	4	2	0	3	0	11
53	0	2	2	0	0	0	4
54	0	4	2	0	0	0	6
55	0	2	2	0	0	0	4
56	1	0	0	0	0	0	1
57	0	0	4	0	0	0	4
58	1	4	4	5	0	0	14
59	3	2	4	0	0	0	9
60	0	4	4	0	0	0	8
61	2	0	0	0	3	0	5
62	1	2	4	0	3	0	10
63	0	2	2	0	0	0	4

APPENDIX P.--Average PAR scores from the polybite-polyvinylsiloxane impressions study models three observations

TABLE 14.-- Average PAR scores from the polybite-polyvinylsiloxane impressions study models three observations

ID	UAS	RBO	LBO	OJ	OB	CNT	TOTAL
1	2	4	4	5	3	0	18
2	1	2	2	0	0	0	9
3	1	2	0	0	3	0	8
4	2	4	4	0	3	0	13
5	0	2	4	0	0	0	7
6	5	4	2	0	3	0	14
7	0	2	4	0	0	0	8
8	2	0	0	0	0	0	2
9	2	4	4	5	3	0	18
10	2	6	2	0	6	0	14
11	1	6	6	0	0	0	13
12	1	0	2	0	3	0	8
13	2	2	2	0	0	0	6
14	0	2	4	0	3	0	9
15	0	2	2	0	0	0	4
16	1	2	4	0	0	0	3
17	2	4	2	0	3	0	9
18	2	4	2	0	0	0	8
19	1	2	2	0	0	0	5
20	0	4	6	5	3	6	24
21	0	0	4	0	3	0	5
22	3	2	4	0	3	0	10
23	0	2	2	5	0	0	10
24	1	4	4	0	0	0	11
25	2	6	2	0	0	0	10
26	0	4	4	0	3	0	11
27	1	2	2	5	0	0	10
28	1	2	2	0	0	0	5
29	3	2	2	0	0	0	6
30	0	2	4	0	0	0	6
31	0	4	4	0	3	0	7
32	0	2	2	0	3	0	7
33	1	2	4	5	3	0	15

TABLE 14.-- Average PAR scores from the polybite-polyvinylsiloxane impressions study models three observations (Continued)

ID	UAS	RBO	LBO	OJ	OB	CNT	TOTAL
34	0	0	4	0	0	0	4
35	0	2	0	0	3	0	7
36	0	4	4	0	3	0	9
37	1	0	0	0	0	0	1
38	1	4	2	0	0	0	9
39	0	2	2	0	0	0	4
40	0	4	4	0	3	0	11
41	1	0	0	0	3	0	4
42	2	2	2	0	3	0	11
43	1	0	2	0	0	0	3
44	2	4	4	5	3	0	18
45	2	2	2	0	3	0	11
46	1	2	4	0	0	0	7
47	1	0	4	0	3	0	8
48	1	4	2	0	0	0	7
49	1	2	2	0	0	0	5
50	2	4	4	0	3	0	13
51	4	2	4	5	3	0	17
52	2	4	2	0	3	0	11
53	0	2	0	0	0	0	2
54	0	4	2	0	0	0	6
55	0	2	2	0	0	0	4
56	1	0	0	0	0	0	3
57	0	0	4	0	0	0	4
58	1	2	4	0	0	0	7
59	3	2	2	0	0	0	5
60	0	2	4	0	0	0	6
61	2	0	0	0	3	0	5
62	1	2	2	0	3	0	10
63	1	2	2	0	0	0	5

APPENDIX Q. -- PAR data by the primary examiner
for the reliabilty of the intraoral method

TABLE 15. -- PAR data by the primary examiner
for the reliabilty of the intraoral method

ID	UAS	RBO-Ap	RBO-vert	RBO-trans	RBO	LBO-ap	LBO-vert	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	CNT	TOTAL
1-I	1	0	0	0	0	1	0	0	2	0	1	5	0	0	0	0	8
2-I	0	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	4
3-I	1	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	7
4-I	1	0	0	2	4	0	0	1	2	0	0	0	1	0	3	0	10
5-I	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	5
6-I	2	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	8
7-I	2	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	6
8-I	7	1	0	0	2	1	0	0	2	1	0	5	1	0	3	3	22
9-I	1	1	0	3	8	0	0	2	4	0	0	0	1	0	3	0	16
10-I	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	7
11-I	1	1	0	0	2	1	0	0	2	1	0	5	0	0	0	0	10
12-I	2	1	0	0	2	2	0	2	8	1	0	5	0	0	0	3	20
13-I	2	1	0	0	2	0	0	0	0	0	0	0	0	1	3	0	7
14-I	3	1	0	0	2	1	0	3	8	0	0	0	0	0	0	0	13
15-I	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
16-I	1	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	5
17-I	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	6
18-I	2	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	4
19-I	1	1	0	1	4	2	0	0	4	0	0	0	1	0	3	0	12
20-I	2	2	0	0	4	2	0	0	4	0	0	0	0	1	3	0	13
21-I	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	7
22-I	1	0	0	0	0	1	0	0	2	0	0	0	0	1	3	0	6
23-I	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	5
24-I	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
25-I	1	1	0	0	2	1	0	1	4	0	0	0	0	0	0	0	7
26-I	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	5
27-I	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	7
28-I	3	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	5
29-I	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	2
30-I	2	0	0	0	0	1	0	0	2	1	0	5	0	0	0	0	9

APPENDIX R. -- PAR data by the second examiner
for the reliabilty of the intraoral method

TABLE 16. -- PAR data by the second examiner
for the reliabilty of the intraoral method

ID	UAS	RBO-AP	RBO-Vert	RBO-Trans	RBO	LBO-AP	LBO-Vert	LBO-Trans	LBO	OJ +	OJ -	OJ	OB +	OB -	OB	CNT	TOTAL
1-I	0	1	0	0	2	0	0	0	0	0	1	5	0	0	0	0	7
2-I	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	2
3-I	1	2	0	0	4	2	0	0	4	0	0	0	0	0	0	0	9
4-I	1	1	0	1	4	1	0	1	4	0	0	0	1	0	3	0	12
5-I	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
6-I	2	1	0	1	4	0	0	1	2	0	0	0	0	0	0	0	8
7-I	2	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4
8-I	7	1	0	0	2	1	0	0	2	1	0	5	1	0	3	3	22
9-I	1	2	0	3	10	0	0	1	2	0	0	0	1	0	3	0	16
10-I	1	1	0	1	4	1	0	0	2	0	0	0	0	0	0	0	7
11-I	0	0	0	0	0	1	0	0	2	1	0	5	0	0	0	0	7
12-I	2	1	0	0	2	2	0	2	8	0	0	0	0	0	0	3	15
13-I	2	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	9
14-I	3	1	0	0	2	1	0	3	8	0	0	0	0	0	0	0	13
15-I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-I	2	2	0	0	4	1	0	0	2	0	0	0	0	0	0	0	8
17-I	0	1	0	0	2	2	0	0	4	0	0	0	0	0	0	0	6
18-I	2	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	4
19-I	1	2	0	1	6	1	0	0	2	0	0	0	1	0	3	0	12
20-I	1	2	0	0	4	1	0	0	2	0	0	0	0	1	3	0	10
21-I	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	7
22-I	1	1	0	0	2	1	0	0	2	0	0	0	0	1	3	0	8
23-I	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
24-I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-I	1	1	0	1	4	1	0	1	4	0	0	0	0	0	0	0	9
26-I	1	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	5
27-I	0	1	0	0	2	1	0	0	2	0	0	0	1	0	3	0	7
28-I	3	1	0	0	2	1	0	0	2	0	0	0	0	0	0	0	7
29-I	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	2
30-I	2	1	0	0	2	0	0	0	0	1	0	5	0	0	0	0	9

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