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Variations in Bracket Placement in the Preadjusted Orthodontic Appliance

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VARIATIONS IN BRACKET PLACEMENT IN THE PREADJUSTED ORTHODONTIC APPLIANCE

by

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DEDICATION

To my parents, Mr. Neguib and Emma Balut,
for their sacrifices throughout my
education and for their
inspiration.

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VITA

The Author, Nasib Balut Chahin, is the son of Neguib Balut and Emma Chahin. He was born may 25, 1961, in Mexico city.

His elementary and secondary education was obtained in Colegio Cristobal Colon; He graduated High School in 1976.

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His publications include "Halitosis" in the Journal of Patologia Quirurgica Citologica Exfoliativa.: Vol. 10:4,1984.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PICTURES

LIST OF TABLES

CONTENTS OF APPENDICES

CHAPTER I

INTRODUCTION

Angle in 1928 recommended angulation of posterior brackets to produce desired tooth movement without resorting to detailed arch wire adjustments: "This permits the use of the arch in its simpliest form, or that freest from bends, which of course has its advantage". Angle's idea was later expanded by other clinicians to include tipping of maxillary anterior brackets and, finally, angulation of rectangular slots of maxillary anterior brackets just as with Angle's tipped posterior brackets, anterior bracket tipping and slot angulation produce desired tooth movement without arch wire adjustments.

In 1971 an edgewise appliance that represents the logical extension of Angle's original concept was made commercially available. All of the brackets had incorporated into them control of tooth movement in three planes of space, thereby producing, in conjunction with arch wires, tip, torque, and in/out movement simultaneously on all teeth.

The objective of all these appliances is to produce desired tooth movement with a minimum amount of wire adjustments.

The preadjusted bracket system is the most widely used in orthodontic therapy today (J.C.O.: Sept.1986). The basic premise of the pre-adjusted bracket system is that proper bracket position allows the teeth to be positioned with a straight wire into an ideal occlusal articulation, i.e.

Ideal Occlusal Contacts

Ideal Tips (Mesio-Distal Inclinations)

Ideal Torque (Facio-Lingual Inclinations)

Clinically, the preadjusted system appliance did not eliminate the wire bending because the patients vary as far as tooth morphology and malocclusions are concerned and their variations from the straight wire appliance average must be compensated by properly adjusting the arch wires.

Experience of many orthodontists who utilize the pre-adjusted bracket system have shown that ideal bracket position is difficult or impossible to attain.

Very little has been written about statistical evaluation and importance of the orthodontic bracket position.

The purpose of this study is to evaluate variations in placement in the vertical and angular bracket position utilizing a preadjusted orthodontic appliance. ("A Company") Positional discrepancies were measured between bracket pair from a horizontal reference line. Variations were evaluated with respect to the classification of malocclusion, specific tooth type and intra/inter operator differences.

CHAPTER II

REVIEW OF THE LITERATURE

Bracket placement and tooth morphology

The orthodontic literature is overwhelmed with the amount of writings (1,4,5,10,16,23,26,28,32,33) concerning methods of positioning the bands and brackets on the teeth or concerning the brackets themselves, since bonding was introduced in orthodontics.

A common argument in that controversy has been the establishment of a certain reference point or points on the teeth for the bracket orientation. The selection of these points must be easy, accurate and reproducible.

Originally it was thought that the best position of the band was where it fits better mechanically. Then, if it were possible, the bracket should be placed at the center of the labial surface of the tooth, unless the tooth was rotated (7). Later, it was recommended (32) to place the bands, preformed or not, on the maxillary incisors at the junction of the middle and incisal thirds and on the lateral incisor, approximately 1 mm. more to the incisal than on the central. The exact location of the band on those teeth had to be determined also by other factors like the length of the clinical crown or the treatment mechanics. Similar considerations were taken into account for banding the rest of the teeth (32). Generally with this method, it was desirable that the brackets at the end of the banding were positioned at certain distances from the tips of the cusps of each tooth.

Ricketts (26) thought and advocated the use of marginal ridges as guidelines for band and bracket vertical positioning. Later, when the preadjusted bracket system (straight wire appliance) was introduced, the position of the bracket itself became more important than the position of the band in order to get the desired results with unbent arch wires. In this fashion, Roth (28) explained how the bands should be positioned when preadjusted brackets are used.

Andrews in a series of articles (3,4,5,6) finally introduced the bracketing technique in placing the straight guidelines of the bracket (vertical tie-wings and/or the welding tabs for molar tubes) parallel to the long axis of the clinical crown and then moving the bracket up or down until the middle of its slot base is at the same height as the LA-point (midpoint of the clinical crown), he called this imaginary line the Andrews plane.

Dellinger (10) found that the Andrews plane was erratic and inconsistent because of the variations in cuspid height, he pointed out that as the bracket is moved occlusally or gingivally on the Andrews plane or LA point, the convex nature of the labial or buccal surface of the teeth reflects differences in torque values.

The controversy and the various ideas and methods of bracket positioning which have been advocated and used by the orthodontist, bring up a matter which might be the reason for the lack of one universally accepted method of bracket positioning. This is the variation in tooth morphology, either as a result of nature's tendency to make the teeth similar but not identical, or as a result of wear of the clinical crowns due to function which for orthodontic patients some times is not measurable (22).

From the orthodontic stand point, the anatomy of the teeth is as important as for all the dental specialities and it is closely related to the placement of the orthodontic brackets. The buccal or labial surface of the teeth, viewed both bucco-lingually and mesio-distally (22), deserves special attention.

Wheeler (40) describes the curvatures above the cemento enamel junction as constant arcs. Each group of teeth, maxillary anteriors, maxillary posteriors, mandibular anteriors, mandibular posteriors, exhibit an arc of curvature that is characteristic both as to location of the curvature and as to the extent of it. He pointed out that according to his observations, the variation from the average curvature will be uniform for any individual's teeth.

In orthodontics, what affects the design of the orthodontic appliance and their use, is the inclination of the labial or buccal surface of the tooth crown to the long axis of either the entire tooth or the crown alone.

Kraus (21) pointed out that the maxillary central incisor may show a wide range of variability, particularly with regard to the labial surface, labial lobes, grooves, the mammelon, the angulation and the size of the roots. The maxillary lateral incisors show a wide range of morphological variations with respect to the labial outline, angulation, mesial and distal surfaces and root curvature.

For the mandibular incisors, the author emphasized that besides other variation in morphology, there is a variability in the degree of inclination of the labial profile to the long axis of the teeth. For the mandibular canines a wide range of variability was found in the degree of "bending" of the crown relative to the longitudinal axis of the tooth. In the same fashion, a significant variation was noticed among the teeth of the same type concerning most of their characteristics.

Taylor (35) found great variations in tooth morphology, as far as the curvatures, of bends in axes of crown and root, the labial outlines and dimensions are concerned. These variations, sometimes, are dramatically exaggerated by the abnormal function wear that the teeth may experience. Also he pointed out that these variations in morphology are due to family characters, personal characters and ethnic characters.

A number of instruments, including the Boone Gauge, have been used for accurate positioning of brackets in direct bonding. Although position adjustments can be made with such an instrument, the bracket can easily slip when the instrument is removed prior to setting of the adhesive. Indirect bonding may be a solution, but it is time consuming and does not provide for precise repositioning of those brackets that fall off during treatment (12).

Bonding of the orthodontic appliance offers a choice of two methods. The direct technique and the indirect technique, the basis of the indirect technique is the laboratory placement of the appliance on a working model of the dental arch; the appliance is transferred to an impression used as a transfer medium to the dentition in the mouth. The chief advantage of the indirect technique seems to be the high degree of accuracy with which the appliance can be positioned on the teeth and the dramatic decreases in required patient chair time (39).

Most current concepts of indirect bonding techniques are performed around the procedure developed and perfected by Cohen and Silverman. Their method of bonding brackets is based upon the use of a tray holding the brackets and positioning them by relating the tray to the occlusal surface of the teeth. This concept is simple and extremely accurate (30,36).

Incorporation of Pre-adjustment in Bracket Design.

In 1928, Edward H. Angle published the first in a series of three articles describing the edgewise appliance. In the second article of the series (7) he recommended angulation of posterior brackets to produce desired tooth movement without resorting to detailed arch wire adjustments: "This permits the use of the arch in its simpliest form, or that freest from bends, which of course has its advantage". Angle's idea was later expanded by other clinicians to include tipping of maxillarly anterior brackets and finally, angulation of rectangular slots of maxillarly anterior brackets. Just as with Angle's tipped posterior brackets, anterior bracket tipping and slot angulation produce desired tooth movement without arch wire adjustments.

Holdaway in 1952, (16) proposed to use the bracket angulation in treatment procedures such as: paralleling of roots adjacent to extraction spaces, setting up posterior anchorage teeth into tipped back positions and artistic positioning of anterior teeth. Specifically for the root paralleling, the bracket on the tooth distal to the extraction space was depressed mesially and the bracket on the tooth mesial to the extraction space was depressed distally. This angulation of the brackets would eliminate the need for second order bends in the wire and it would also parallel or overcorrect the position of the teeth adjacent to the extraction space. This is necessary because, as Holdaway mentioned(16), if the bracket is placed so that the long axis of it is parallel to the long axis of the tooth when the space is closed, the roots will not be parallel unless the wire fits in the slots of the brackets with an absolute accuracy which is not practical. The amount of angulation that Holdaway proposed was 3 degrees towards the extraction space, which he felt was adequate to parallel the roots when .021 inch arch wire was used with .022 X .028 inch "edgewise" brackets. He also mentioned that for anchorage preparation the bracket angulation of 2-3 degrees to keep the teeth upright, or 10-12 degrees to tip them back will give the best results.

Dr. Jarabak (17) proposed a treatment method that used "edgewise" brackets which had third order adjustments incorporated into them (facio-lingual angulation). The amount of the preadjustment varied from tooth to tooth. This feature facilitated the application of third order mechanics (torque), with straight close tolerance rectangular wires. They were used at the later stages of treatment to control the buccolingual or labiolingual axial tooth inclination. He also placed those brackets on the teeth mesiodistally angulated as described by Holdaway. This was used to accomplish second order movements (mesio-distal) of the teeth with straight ligth round arch wires. Dr. Jarabak indicated that the amount of bracket mesio-distal angulation varies according to treatment goals as far as facial esthetics, functional harmony, denture stability, cephalometric standards and tooth morphology are concerned. So, for anterior teeth, he suggested a range of tip from 2 to 4 degrees, the greater being for long crown anterior teeth, whereas the 2 degrees angulation is for short crown teeth. On posterior teeth, the mesial tip varies from 8 to 10 degrees for the mandibular molar tubes and premolar brackets, the greater angulation being used when there is excessive overbite. For the maxillary buccal teeth, the bracket angulation varies from 5 to 7 degrees mesial tip, and at last the bracket angulation is 0 to 7 degrees for maxillary canines and 7 degrees distal tip for mandibular canines (18). The concept of light forces was introduced in orthodontics (8,14,15,) when experimental studies (14,34) gave an idea about the reaction of the periodontum to tooth movement. It was shown that light round wires exert more physiologic forces. The response to that was a move towards the use of light and resilient round wires instead of close fitting rectangular arches. This resulted in the development of the light wire philosophies and techniques.

Dr. Jarabak (18) mentioned that mesio-distal uprighting can be accomplished by incorporating second order bends into the arch wire as well as properly altering the orientation of the brackets on the teeth. The bending of the arch wire is complicated when first and third order bends are made simultaneously with the second order ones. While the angulation of the brackets can easily and simply control the mesio-distal tooth uprighting, the latter means that instead of soldering the bracket parallel to the edges of the metal bands, it has to be placed so that the long axis of the bracket forms a certain angle to the long axis of the tooth. Subsequently, the arch wire engaged into angulated slots would tend to upright the teeth. This method was an improved way of uprighting the teeth, because it permitted to use arch wires free from second order bends which were difficult to make or repeat in subsequent wire changes (29).

The orthodontic bracket has been a key element in the achievement of treatment goals and the improvements in its design were real advancements in the development of orthodontic appliances. The bracket must be defined as being a device to be attached on the teeth which is capable of transmitting the desired forces derived from the arch wire to the teeth and produce the desired tooth movement (25).

Mesio-Distal bracket angulation and buccolingual or labiolingual slot angulation to tip and torque the teeth respectively, were applied by many orthodontists. They intended to minimize wire bending and make their technique more efficient by eliminating error, which was introduced due to the play and any smaller rectangular arch wire experiences in a larger bracket slot (12). The idea was probably the forerunner of the preadjusted appliance treatment concepts.

The rotating and translating effects of a single force applied to an object, such as a tooth, are described in the terms of moments. Moments are measured by the product of the applied force times the shortest distance from the center of rotation of the tooth to the line of the force Fig. 1 . If two parallel forces of equal magnitude are applied to a tooth in opposite directions, they cancel each other as linear forces and produce a pure rotation of that tooth; these paired forces are called a couple. A couple creates moments of rotation. The moment of a couple can be measured by multiplying one of the forces of the couple by the distance separating the lines of the force. When a couple is operating, the moment of rotation is the same at all points in the body being acted upon regardless of the point of application of the forces (Fig.2). All the forces delivered by the interaction of a wire in a preadjusted edgewise bracket can be described in terms of moments or couples or their combinations.

In order to produce mesial or distal tipping movements, a bracket configuration that creates a couple at the bracket wire interface is used as shown in Figure 3. So the couple is produced by a bracket tipped on its base or a slot that is angulated within the bracket.

The same design principle applies to preadjusting for torquing tooth movements. Torque, as we use the term in orthodontics, simply means a rotational force in a labio-lingual or buccolingual direction. (Fig.4) Torquing forces are developed by the interaction of rectangular wires in rectangular wire slots. This interaction produces a couple at the bracket, the preadjusted appliance reacts clinically in a different way as a conventional edgewise appliance. It reacts in a significantly different manner. Torque, tip, and in/out adjustments operate within the appliance concurrently (23,27).

A preadjusted or straight wire appliance (S.W.A.) was introduced by Andrews (2,3,4,5,6) in 1970. It does not imply a new mechanism, but it is a modified edgewise appliance. The modification is that preadjusted bracket

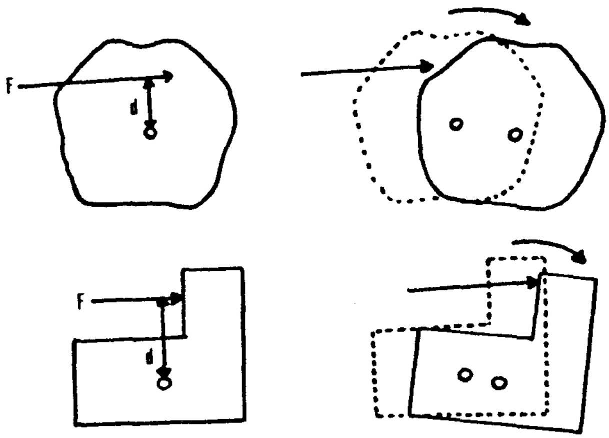


Figure 1

The rotating effects of a single force applied to an object are described in terms of moments. Moments are defined as force (F) times distance (d): M=Fd. Note that two movements occur: Rotation and Translation.

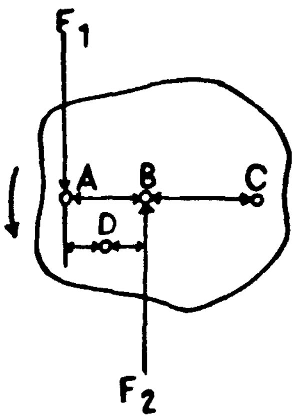


Figure 2

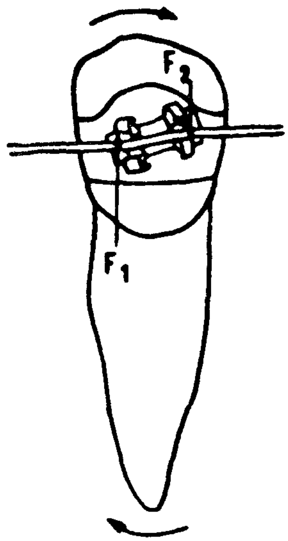


Figure 3

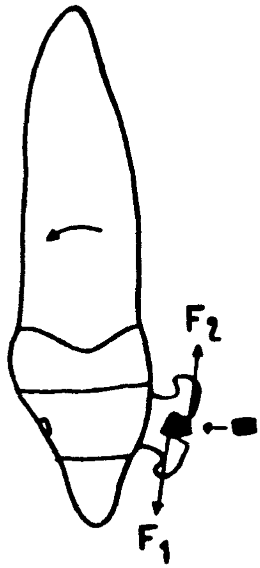


Figure 4

Fig. 2 Moments of Rotation. Two equal forces are acting in the same plane on this body. The moment of rotation (M=Fd) is the same at points A,B,C,D, or any other selected point.

Fig. 3 Tip. Built-in Tip produces a moment of rotation as a result of the force couple (F_1 and F_2).

Fig. 4 Torque. Built-in Torque produces a moment of rotation as a result of a force couple (F_1 and F_2).

systems have certain characteristics built into the brackets for the tipping, torquing, and first order compensating movements of the teeth. Theoretically, these movements are accomplished when the brackets, after being properly placed on the teeth, and engaged to full sized arch wires. The fixed preadjustments dictate the direction and extent of the tooth movements and they are of such magnitude as to bring any individual tooth to its ideal position in the dental arches. The ideal positions of the teeth, and therefore the corresponding preadjustments were determined based on scientific observations as to what is normal occlusion for non-orthodontic patients. One hundred and twenty casts of non-orthodontic patients with normal occlusions were studied. Some conclusions were derived concerning the position of the teeth individually within the respective arches and the relations of the teeth to each other collectively. These conclusions were summarized as constant findings exhibited by all the examined casts as "the six keys to normal occlusion" (2).

1. The molar relationship was found to be normal when the distal surface of the distobuccal cusp of the upper first permanent molar made contact and occluded with the mesial surface of the mesiobuccal cusp of the lower second molar. The mesiobuccal cusp of the upper first

permanent molar fell within the groove between the mesial and middle cusps of the lower first permanent molar.

2. The second observation referred to the crown angulations, or the mesiodistal tip. It was pointed out that, the long axis of the crown of the teeth, indicated by the middevelopmental ridge of the buccal or labial surface of all the teeth except molars and the vertical groove on the buccal surface of the molar was inclined in such a way that the gingival portion of it was distal to the incisal portion varying with the individual tooth type.

3. The labiolingual or buccolingual crown angulations, or crown axis angulations was determined to be:

a) For centrals and laterals such that permits normal overbite and posterior occlusion.

b) For upper posterior teeth, lingual constant and similar from the canines through the second premolar and slightly more pronounced in the molars, and

c) For lower posterior teeth, lingual progressively increased from canines through the second molars.

4. There were no rotations observed.

5. There were no spaces between teeth.

6. The plane of occlusion varied from flat to a slightly curved.

The preadjusted bracket system was designed for the purpose of achieving these "six keys to normal occlusion" for the orthodontic patients. That is carried out by the characteristics incorporated into the preadjusted brackets which are:

1. The mesiodistal preangulation of the slots within the brackets.
2. The inclined bases. (Relative to the slot facio-lingually)
3. The contoured bases.
4. The varying thickness of the bases from tooth to tooth.
5. The building of the preadjustments. (Tip-Torque-in/out) into the brackets according to the "six keys to normal occlusion".
6. The fact that these brackets in order to express their built in treatment as

predetermined, should be centered on the L.A. points (centers of the tooth clinical crowns).

The application of the preadjusted bracket system demands the definition of the exact orientation and position of the preadjusted brackets on each individual tooth. That involves the vertical positions as well as the angular alignment of the brackets. Mistakes in placing the preadjusted brackets on the teeth affect the amount of the tip, torque and in/out adjustments produced by the brackets.

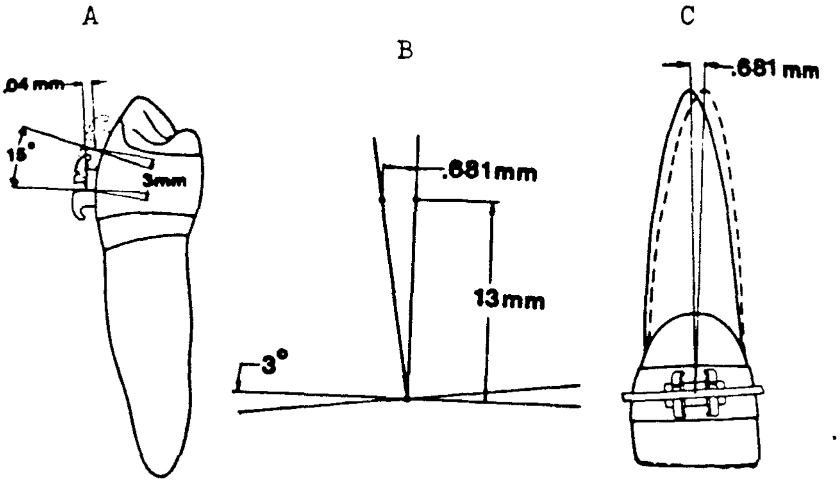
The S.W.A. is designed to produce ideal final tooth position. Each bracket has its maximum adjustment from the beginning. Incremental adjustments are achieved by gradually increasing the wire size, rather than by sequential wire adjustements. Final ideal tooth positions result from maximum expression of the preadjusted attachments. Maximum slot expression is achieved by placement of "full-sized wires" (that is wire size and bracket-slot size nearly the same). If full-sized wires are not used, complete expression of built-in adjustments will not occur (23).

Thurow showed(37), that two different vertical positions of a bracket, on a tooth, will cause two different buccolingual axial inclinations (torque).

Meyer and Nelson (23) specifically pointed out that an error of 3mm. vertically in bracket placement on premolars can result in 15 degrees torque alteration and .04 mm. alteration in the applied in/out adjustment. An error, also, of bracket positioning decreases or increases the slot angulation, may result in different than expected mesiodistal axial inclination of the teeth.(fig.5) Dr. Andrews advocated the use of specific landmarks on the teeth for the angular and linear orientation of the preadjusted brackets. They are the long axis of the <u>clinical crown</u> on its long axis (La reference point). In relation to these reference marks, it was found (non-orthodontic patients) that the crown tip for the maxillary central incisors is 5 degrees. This is the angle formed between the crown axis (LACC) and a line perpendicular to occlusal plane. The crown torqued measured as the angle between the same perpendicular line and a tangent to the crown at the LA reference point was 7 degrees. Therefore, when the preadjusted bracket is placed properly on the tooth, it will provide 5 degrees mesiodistal angulation and 7 degrees torque. In other words, a line perpendicular to the slot plane will form an angle of 5 degrees with the long axis of the crown and 7 degrees with a tangent to the midpoint of the crown. Clinically, when a full sized straight rectangular arch wire is engaged into this slot, the tooth will show the expected amount of tip and

Figure 5

ERRORS IN BRACKET PLACEMENT



A: A 3 mm. error of placement in the vertical direction results in alteration of 15 degrees in the Torque and .04 mm in the in and out adjustments.

B,C: A 3 degree error in bracket placement results in 0.68 mm deflection of the root Tip, being 13mm. away from the bracket center. (Meyer and Nelson 23).

torque. When the brackets are all placed on the teeth perfectly oriented to the reference marks, they will also compensate for the difference in thickness between the various tooth types in every arch. That is because there are first order adjustments incorporated into the brackets, expressed as different bracket thickness for different tooth types in every arch.

The slots of the preadjusted brackets, as Andrews explained (29) are angulated specific degrees for each tooth. In reference to the vertical components of the brackets, the proper angular orientation is achieved only when the vertical components of the bracket (wings) are parallel to the crown axes of the teeth (LACC). That ensures that the slots in that case, are properly angulated on the teeth. The inclined bases facilitate the vertical positioning of the S.W.A. brackets. When they are centered on the LA points, the bracket slots are also centered on those points (LA point, center of the base and center of the slot are on a straight line). As Andrews submits (5) the LA points compose a plane when the teeth are aligned. Therefore, when the brackets are centered on the LA points, a straight arch wire will tend to align the slots vertically and therefore the teeth. The tooth side of the base of the brackets are contoured both vertically and horizontally, specifically for each tooth type, so they fit absolutely on the tooth surface on a specific area. That feature facilitates the vertical, angular and mesiodistal orientation of the bracket, because it guides the bracket to be placed on the right spot. It is assumed that the slot will be centered on the LA point and the wings will parallel the crown long axis, when the base is placed where it fits the best.

When the S.W.A. was introduced, some clinicians felt, that even during the initial leveling of the teeth with the S.W.A., more angulation is needed than with the standard edgewise appliances. Dr. Andrews mentioned that the S.W.A. does not require more anchorage, but on the contrary, it is more efficient from the standpoint because the errors in placing the brackets on the teeth were claimed as fewer with S.W.A. when the instructions are followed and therefore, some unecessary tooth movements may be avoided. Also, with the S.W.A. technique the wire bending is minimized. This means that the teeth move among direct vector lines from the maloccluded position to the correct one, guided by the features built into the brackets (3,5).

Another issue of the argument on S.W.A. was related to the range within which the S.W.A. concept can be applied regardless of the differences in tooth morphology from patient to patient. Dr. Andrews has mentioned that the "central tendency" existing as nature's wisdom to make "most of any one species more alike than unlike", makes it possible for him to treat about ninety per cent of his nonextraction patients with the standard S.W.A. and almost unbent arch wires. Fifty percent of the extraction series brackets and arch wires slightly bent (3).

The standard non-extraction S.W.A. brackets, are programed to provide certain angulation (TIP) of the slot, torque and in/out compensations. The brackets of this type are not adequate in controlling the axial position of certain teeth in extraction cases. Those teeth either have to be moved through an extraction space or to serve as resistance source (anchorage). The S.W.A. extraction series, anticipates the need for the additional anchorage requirements and greater bodly movement of certain teeth through extraction spaces.

Dellinger, in 1978 (10), questioned the validity of the S.W.A. theory and he conducted a study of 50 cases to examine the assumptions on which the S.W.A. concept was based. He wanted to verify whether or not it is true that there is "a certain fixed" consistent inclination (torque) of the labial or buccal surfaces of all teeth and a consistent difference in the buccolingual dimension among the different tooth types. He pointed out that there was a significant variation in inclination of the buccal or labial surfaces of all the teeth among the fifty studied cases. Dellinger concluded that the required arch wire bending with the S.W.A. is almost as much as with any standard edgewise techniques. The variation does not show very dramatically when smaller than full sized arch wires are used, because of the loose fit that the arch wire experiences in the slot. If, however, full sized arch wires are used, in order to get all the built in treatment, a great deal of wire bending is necessary to compensate for the tooth morphology variations.

A statistical evaluation of torque data in treated and untreated groups with ideal occlusions were studied by Vardimon and Lambertz (38) after evaluating the mean torque values from different authors they concluded that there is a close agreement with Andrews mean torque values except those for the upper incisors which fluctuates between 7° (Andrews, Burstone,Creekmore) and 22° (Rickets, Hilgers) they pointed out the maximal arch wire in a 0.018 inch slot that will not produce deleterious effects is 0.016 X 0.022 inches using Andrews data and 0.016 X 0.016 inches with Rickets data.

Roth in 1975 (27), evaluated the preadjusted bracket system after he used it for five years. He found the preadjusted system compared to the standard edgewise mechanism more efficient, because it accomplishes the desired tooth movements by preadjusting the brackets instead of bending the arch wires. He asserted that the preadjusted system eliminated most of the variables introduced in the manipulation of the standard edgewise appliance due to wire bending. At the most, as he pointed out, two dimensions (tip and torque) of tooth movement can be accomplished, conventionally, by approximately angulating the standard brackets and torquing their slots. With the preadjusted system, the desired tooth position of all the teeth are predetermined into the brackets in all three planes of space, (tip,torque,in/out). According to Roth, the advantages of the preadjusted bracket system can be listed as follows:

1. Ease of wire construction since most of the times it is limited in giving the proper arch form and reverse or compensating curves.
2. No restrictions in the use of the interbracket span since theoretically there are no bends to interfere with the tooth movements.
3. Easier insertion of rectangular arch wires into the slots after the initial leveling.

4. Less round tripping.
5. Better control of tooth positions at any stage during treatment because the amount of treatment built into the brackets is limited by the desired end result.
6. Better and more consistent results at shorter treatment time.
7. Patient comfort.
8. Ease of ligation since every bracket is customized for each tooth type.
9. Easier bracket placement.

Roth, in 1981 (28) modified the S.W.A. by changing the amount of the preadjustments built into the brackets. His objectives were to have the teeth in overcorrected positions at the end of treatment when unbent, full sized wires were used. The purpose of introducing the overcorrection in certain areas in the dental arches was to enable the orthodontist to control the relapse of the teeth, after the active treatment, into an arrangement which is in absolute harmony functionally and esthetically.

CHAPTER III

METHODS AND MATERIALS

The sample chosen for this research consisted of five untreated orthodontic patients models which represented different types of malocclusion. One class I, two class II division I and two class II division II. These cases were taken from the Orthodontic Department at Loyola University, School of Dentistry. The patients models were duplicated using a biostar vacuum formed template and poured in orthodontic laboratory plaster.

Next, a "Diagnostic Set-Up" was fabricated from the duplicated models. The diagnostic set-up is a diagnostic technique which simulates post treatment orthodontic tooth position (20). The laboratory technique involves properly aligning the original malocclusion via manipulation of individual teeth in a wax medium. (Picture 1)

These teeth were positioned to ideal articulation and evaluated as having excellent occlusal contacts using articulating paper (Accu film II). Occluding ideal articulation will be defined as teeth having ideal tip (mesio-distal inclination). (Picture 2)

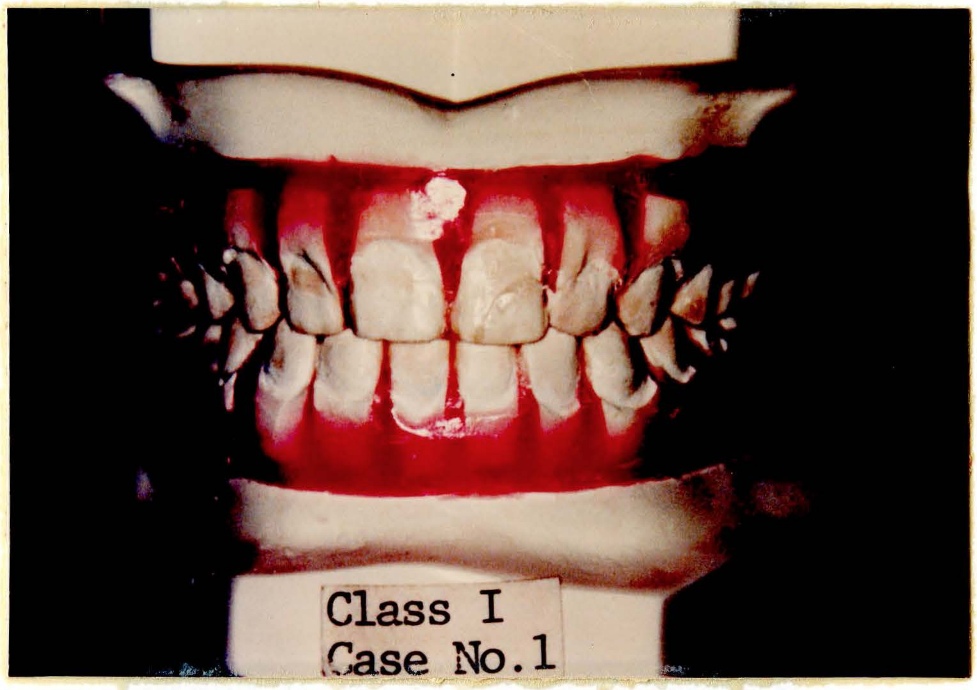
One accurately trimmed occlusal registration was fabricated out of acrylic (Langs) taken from each diagnostic set-up of the individual orthodontic patient's models. The occlusal registration served as a template for the final ideal tooth position.

10 Faculty members from the Orthodontic Department of Loyola University, School of Dentistry were employed in this study. Each faculty member placed the pre-adjusted brackets ("A company") using indirect bonding adhesive (Unitek Co.) on 5 duplicated untreated orthodontic patient models from first molar to first molar inclusively. The models were mounted in a mannequin to simulate the patient's mouth (Picture 3). The models were not occluded and bracket wing interference was specifically excluded as a possible cause of variation in bracket placement.

A total of 50 bonded cases served as the population for this study. (10 Faculty by 5 cases)

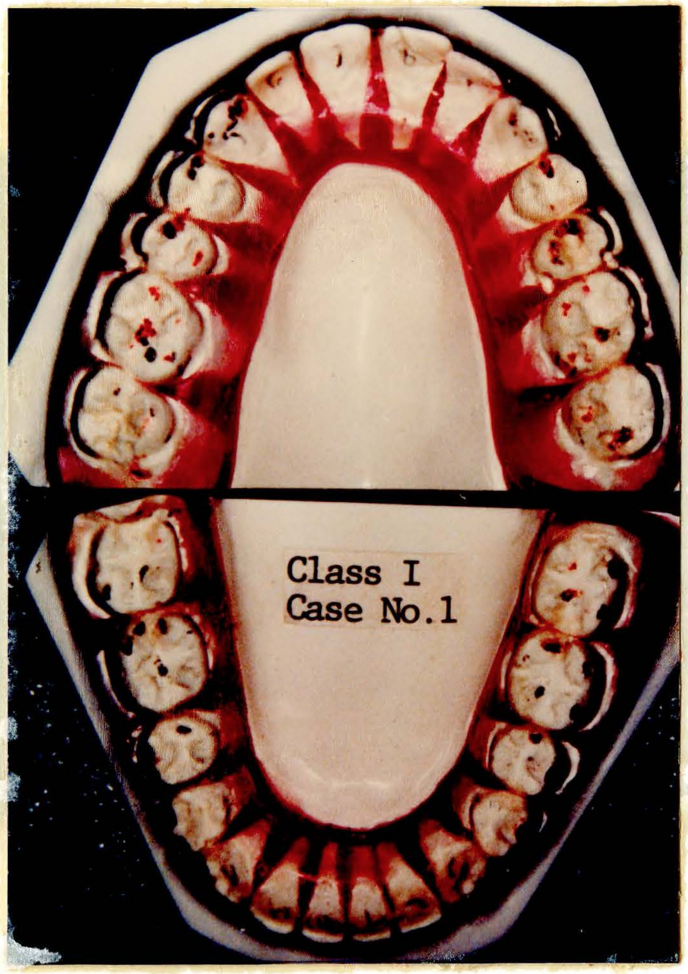
After the brackets were placed on the untreated

PICTURE 1



"DIAGNOSTIC SET - UP"

PICTURE 2



OCCLUSAL CONTACTS.

PICTURE 3

MANNEQUIN TO SIMULATE THE

PATIENT'S MOUTH

models, the teeth were sectioned from the base utilizing an Acretone Die Saw. The sectioned teeth were transferred to the occlusal registration made from the Diagnostic Set-Up and secured in place with adhesive (Cyanoacrylate, Permabond 910).

The sectioned teeth secured with adhesive to the occlusal registration were designated as the "Transfer Set-Up", this is the ideal desired relationship of the finished case, and was evaluated by standardized photographs. (Picture 4)

The standardized photographs were taken on a copy stand in the Orthodontic Department with the transfer Set-Up mounted on a cast stabilizing jig. (Picture 5).

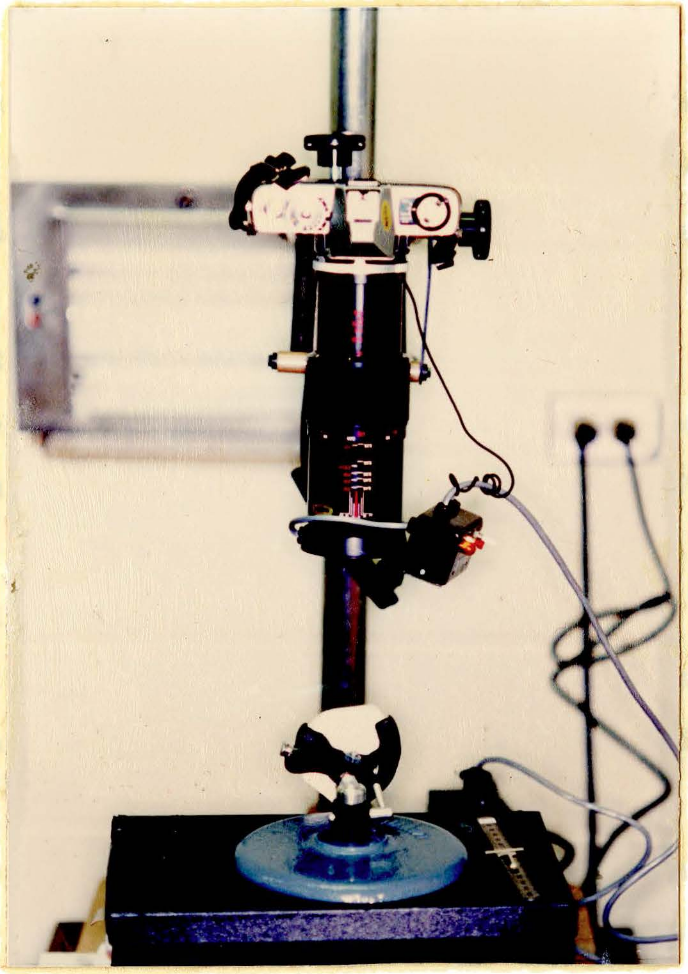
Five photographs were taken of each arch of each transfer Set-Up at a fixed distance using a 90mm. macro lens (Panagord), f2.8, 1:1 a ring light flash attached to the end of the lens, with a Minolta 35mm. single lens reflex camera body oriented perpendicular to the crowns of the teeth. The lens was set on a 1 to 1 magnification ratio, the camera was set at f/16. Kodacolor VR-G 100 Asa Km. 135-36 film was used.

Each photograph covered different segments of the

PICTURE 4

"TRANSFER SET - UP"

PICTURE 5



EQUIPMENT USED IN PHOTOGRAPHIC TECHNIQUE.

transfer set-up:

-Right and left buccal segment exposures: with the camera lens oriented perpendicular to the crowns of the first molar, second premolar and first premolar. (Picture 6)

-Right and left canine exposure: with the camera lens oriented perpendicular to the crowns of the first premolar, canine and lateral incisor. (Picture 7)

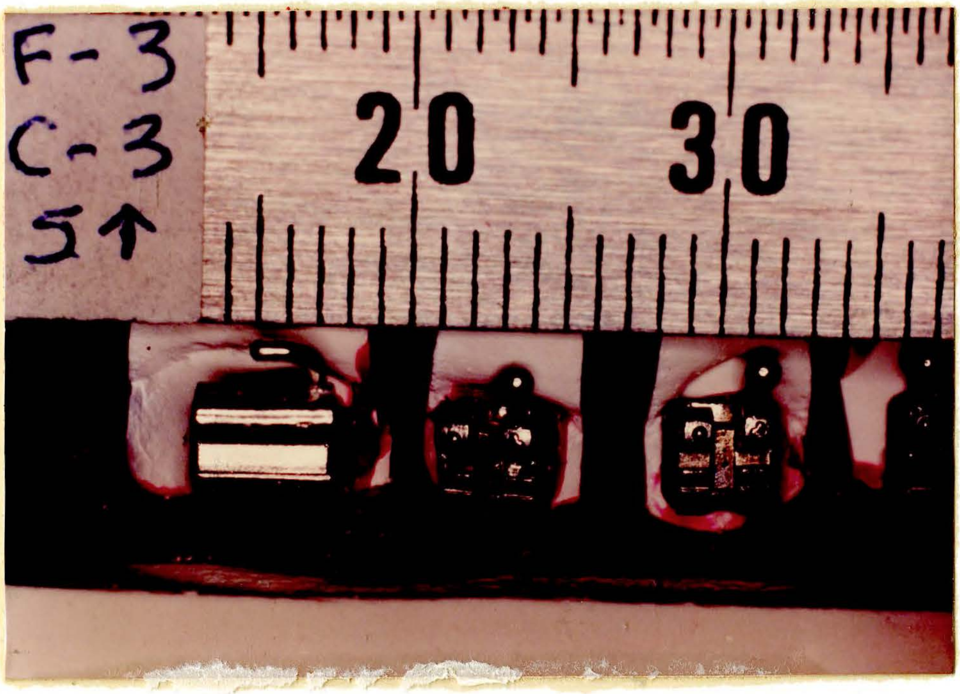
-Incisor exposure: photographs of the incisors were taken with the camera lens oriented perpendicular to the crowns of the four anterior incisors. (Picture 8)

The resulting standardized photographs were digitized on a Houston Instrument HI-PAD Digitizer. The vertical and angular differences in bracket position were measured between tooth pairs by mapping the outer wings of each bracket using a soft ware program written for an IBM Mainframe Computer.

The program performed the following tasks:

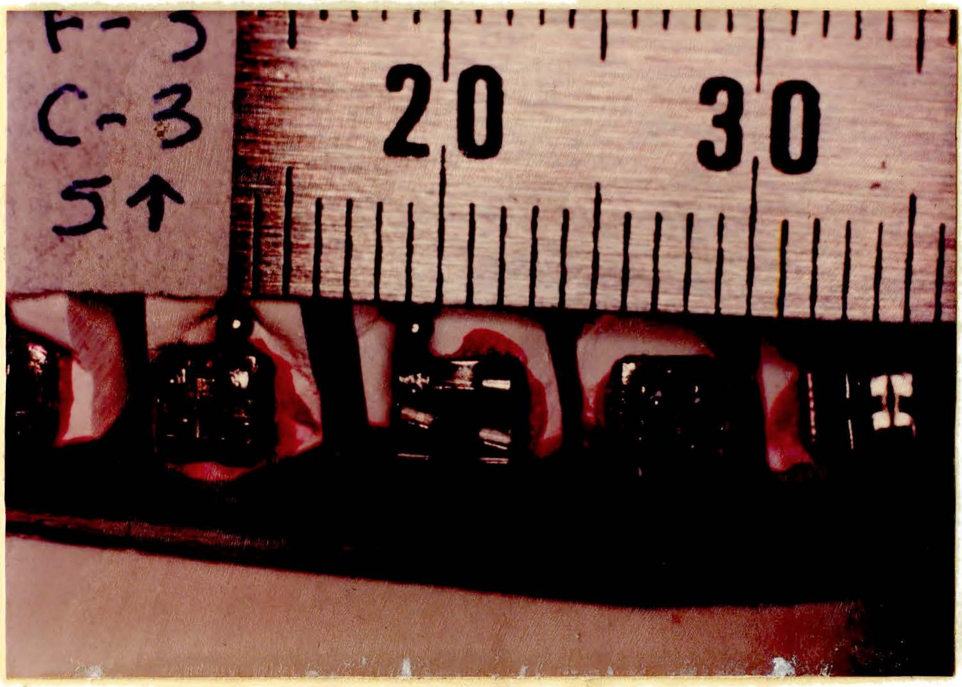
- Accepts data (X-Y coordinate pairs) from the digitizer.

PICTURE 6



EXPOSURE OF THE FIRST MOLAR, SECOND PREMOLAR AND FIRST PREMOLAR.

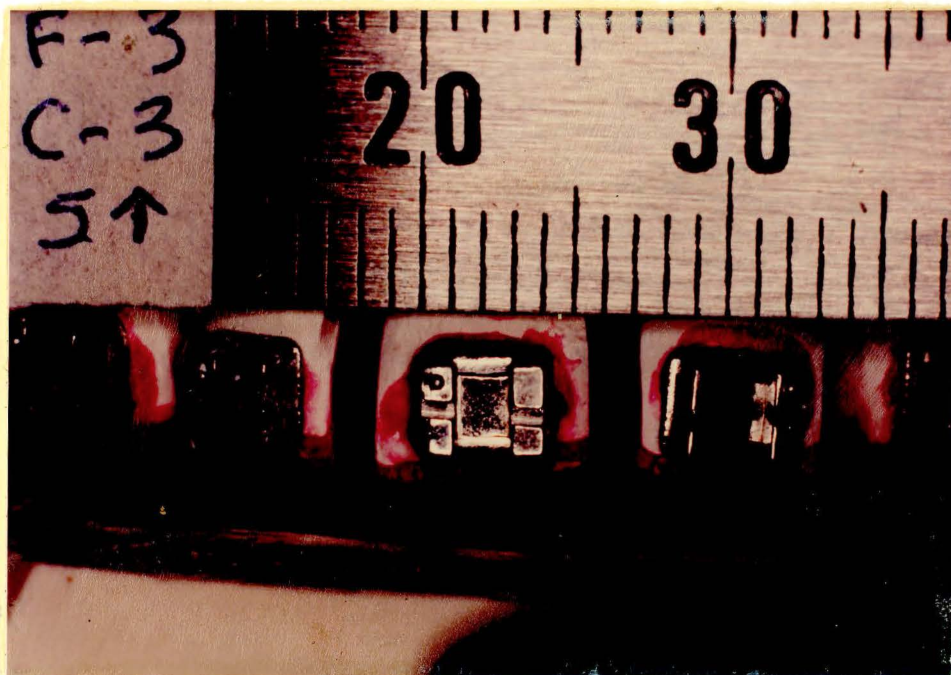
PICTURE 7



EXPOSURE OF THE FIRST PREMOLAR,

CANINE AND LATERAL INCISOR.

PICTURE 8



INCISOR EXPOSURE

- Processes a photograph at a time accepting six pairs of X - Y coordinate points.
- After processing the photographs, calculates the angular and linear discrepancies implementing the appropiate algorithms.
- Stores the original X - Y coordinate pairs, the calculated angular and linear discrepancies values for each pair of teeth, tooth number, faculty number, and model number into a file.

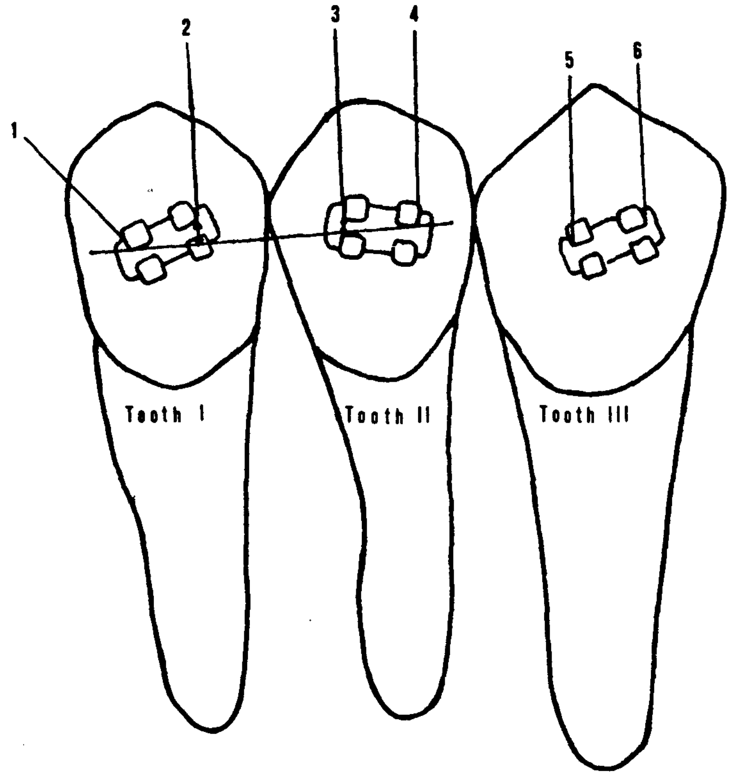
There are six points digitized in from the three teeth in each photograph. Points 1 and 2 are from tooth I, points 3 and 4 are from tooth II and points 5 and 6 are from tooth III. The measurments were calculated from a reference line that was formed by intersecting point 1 and point 4 from tooth I and II. The vertical measurments were calculated by measuring the perpendicular distance of point 2 and point 3 to the reference line (Figure 6). The linear difference is taken as the sum of the values of the lengths (point 2 and 3 to the reference line) if the vector values of the lengths are on opposite sides of the reference line and as the difference of the values if they are on the same side.

The angular measurments were calculated from the difference between the arctangents of the slopes of point 1 and 2, and point 3 and 4.(Figure 7)

If the four points are on the reference line, the linear and angular absolute values will be "zero" from each tooth pair. This would indicate ideal bracket placement on the models.

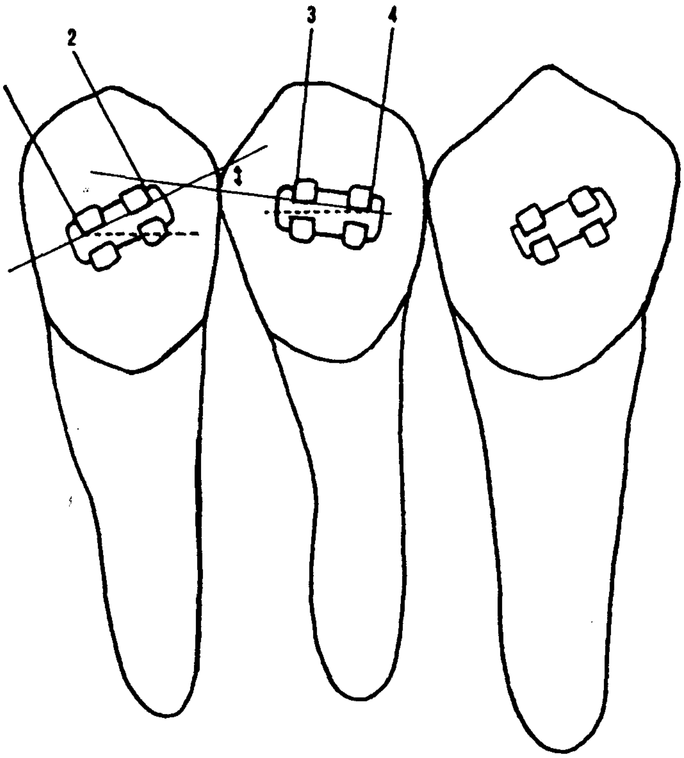
Any deviation from the reference line will be considered a variation from ideal bracket placement.

FIGURE 6



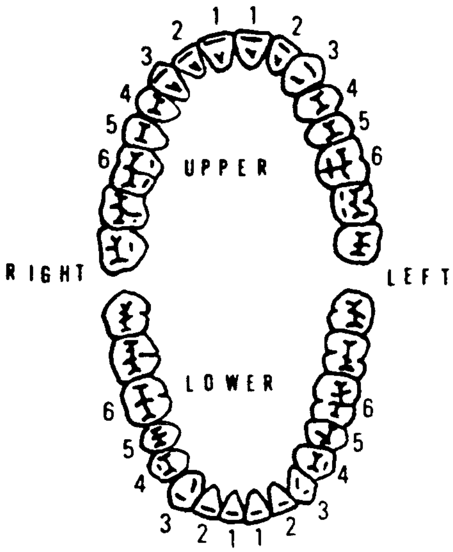
The measurements were calculated from a reference line that was formed by intersecting point 1 and point 4. The vertical measurements were calculated by measuring the distance of point 2 and point 3 to the reference line.

FIGURE 7



The angular measurements were calculated from the difference between the arctangents of the slopes of points 1 and 2 and points 3 and 4.

FIGURE 8



Tooth pairs used to measure the vertical and angular discrepancies.

Upper Right:	6-5, 5-4, 4-3, 3-2, 2-1, 1-1
Upper Left:	5-6, 4-5, 3-4, 2-3, 1-2, 1-1
Lower Right:	6-5, 5-4, 4-3, 3-2, 2-1, 1-1
Lower Left:	5-6, 4-5, 3-4, 2-3, 1-2, 1-1

CHAPTER IV

RESULTS

The experimentally determined error of this study was determined by repeated measurements of two faculty members (10 cases) using a paired "T" test for the linear and angular measurements. A mean of 0.005 mm. of linear difference was found, and a mean of 0.087 degrees of angular difference was found, which was not statistically significant.

The results of the vertical and angular measurements are presented in the following 7 tables. 2-way analysis of variance was used to determine whether differences do exist; multiple comparison procedures were made by a Tukey's HSD Test to determine where the differences exist.

A mean of 0.34 mm., a standard deviation of 0.29mm. and a range of 1.80 mm. for the linear measurements were found.

A mean of 5.54 degrees, a standard deviation of 4.32 degrees and a range of 29.10 degrees for the angular measurements were found.

Values that run from 0.00mm. to 1.80 mm. in vertical bracket displacement and 0.00 degrees to 29.10 degrees in angular bracket displacement were found. (Table No. 1)

Table No. 2 shows the mean, standard deviation and range of the linear and angular discrepancies by faculty, indicating statistically significant differences in bracket position among faculty No. 2, faculty No. 5 and faculty No.6 for the angular measurements, and statistically significant differences between faculty No. 3 and faculty No. 9 for the linear measurements ($P \geq 0.01$).

Faculty No. 2 showed less angular discrepancy than faculty No. 5.

Faculty No. 6 showed less angular discrepancy than faculty No. 5 and faculty No. 9.

There were no statistically significant differences in angular bracket displacement among faculties

No. 1,3,4,7,8,10.

Faculty No. 3 showed less linear discrepancies than faculty No.9 ($P \geq 0.01$).

There were no statistically significant differences in linear bracket displacement among faculties No. 1,2,4,5, 6,7,8,10 ($P \geq 0.01$). Table No. 2

Table No. 3 shows the means, standard deviation and range of the linear and angular discrepancies by models (5 cases).

Model No. 2 showed significantly less angular discrepancy than model No. 5.

There were no significant differences among models in vertical discrepancies ($P \geq 0.01$).

Table No. 4 displays the mean of the angular discrepancies of each faculty by tooth pair. The differences were as follow:

L 2 to 1, L 1 to 1, L1 to 2, U 4 to 5 and L 6 to 5 Showed significantly less angular dicrepancies than U 1 to 1,L 4 to 3 and U 3 to 4.

There were no significant differences among U 4 to 3, L 3 to 4, U 2 to 3, U 6 to 5, U 3 to 2, L 4 to 5, L 2 to 3, L 5 to 6, U 5 to 4, L 3 to 2, U 2 to 1, L 5 to 4, U 5 to 6 and U 1 to 2.

Table No. 5 display the mean of the linear discrepancies of each faculty by tooth pair.

L 2 to 1, L 1 to 1, L 1 to 2, U 1 to 1 showed significantly less vertical discrepancies than U 6 to 5, U 5 to 6, U 3 to 4, U 2 to 1 and U 4 to 5 ($P \geq 0.001$)

There were no significant differences among U 4 to 3, L 3 to 4, L 3 to 2, U 1 to 2, L 5 to 4, L 4 to 3, L 4 to 5, U 5 to 4, U 3 to 2, L 2 to 3, U 2 to 3, L 5 to 6, L 6 to 5.

L=Lower

U=Upper

TABLE 1

$\overline{X}$, S.D., RANGE, MAXIMUM VALUES AND MINIMUM VALUES OF THE LINEAR AND ANGULAR DISCREPANCIES.

	Mean=$\overline{X}$	Standard Deviation - SD.	Range	Maximum Value	Minimum Value
Linear Discrepancies	0.34mm	0.29 mm	1.80mm	1.80mm	0.00 mm
Angular Discrepancies	5.54°	4.32°	29.10°	29.10°	0.00 °

TABLE 2

$\overline{X}$., S.D. RANGE OF THE VERTICAL AND ANGULAR DISCREPANCIES BY FACULTY

FACULTY	MEAN		S.D.		RANGE	
	LINEAR	ANGULAR	LINEAR	ANGULAR	LINEAR	ANGULAR
1	0.38	6.02	0.28	4.54	1.30	20.79
2	0.35	4.87	0.30	4.11	1.62	21.20
3	0.26	5.77	0.22	4.47	1.03	23.61
4	0.33	5.12	0.26	3.71	1.11	17.06
5	0.34	6.76	0.29	5.12	1.56	24.30
6	0.34	4.48	0.28	3.21	1.11	13.06
7	0.31	5.21	0.27	4.07	1.25	18.26
8	0.32	5.40	0.29	3.85	1.36	17.25
9	0.42	6.33	0.34	5.07	1.79	29.01
10	0.36	5.48	0.31	4.31	1.55	19.63
N=110						

TABLE 3

$\overline{X}$., S.D., AND RANGE OF THE LINEAR AND ANGULAR DISCREPANCIES BY MODELS.

Faculty		MODEL 1 $\bar{X}$	MODEL 1 S.D.	MODEL 1 RANGE	MODEL 2 $\bar{X}$	MODEL 2 S.D.	MODEL 2 RANGE	MODEL 3 $\bar{X}$	MODEL 3 S.D.	MODEL 3 RANGE	MODEL 4 $\bar{X}$	MODEL 4 S.D.	MODEL 4 RANGE	MODEL 5 $\bar{X}$	MODEL 5 S.D.	MODEL 5 RANGE
1	LINEAR	0.40	0.26	1.11	0.42	0.26	0.82	0.36	0.27	1.09	0.36	0.35	1.24	0.36	0.26	1.11
	ANGULAR	6.67	4.99	15.77	6.55	5.36	20.46	7.15	4.83	20.38	5.05	3.39	11.78	4.69	3.68	10.89
2	LINEAR	0.26	0.18	0.76	0.36	0.23	0.77	0.35	0.37	1.33	0.40	0.39	1.61	0.40	0.28	1.02
	ANGULAR	5.74	3.72	14.92	4.34	3.96	16.49	4.59	3.40	14.44	4.12	3.86	12.73	5.55	5.43	21.20
3	LINEAR	0.30	0.22	0.80	0.27	0.25	0.96	0.27	0.24	0.70	0.22	0.18	0.57	0.26	0.23	1.00
	ANGULAR	7.17	5.30	22.84	4.50	4.67	18.34	6.35	4.15	14.70	4.73	3.61	13.40	6.10	4.27	15.72
4	LINEAR	0.36	0.26	0.82	0.34	0.26	0.85	0.21	0.21	0.83	0. 36	0.28	1.01	0.37	0.26	1.10
	ANGULAR	4.43	3.69	11.70	4.81	3.38	13.24	4.71	2.91	13.05	5.72	3.73	13.78	5.81	4.74	17.05
5	LINEAR	0.41	0.39	1.54	0.35	0.28	1.18	0.27	0.19	0.69	0.37	0.31	1.02	0.32	0.24	0.92
	ANGULAR	7.53	6.01	20.45	6.03	4.06	16.13	4.64	3.34	14.61	6.45	4.44	16.87	9.15	6.38	24.30
6	LINEAR	0.41	0.35	1.09	0.32	0.21	0.88	0.36	0.27	1.03	0.32	0.26	0.83	0.30	0.28	1.09
	ANGULAR	4.79	3.81	12.28	4.01	3.16	12.00	3.65	2.85	11.38	5.12	3.35	12.52	4.34	2.86	9.93
7	LINEAR	0.23	0.25	0.82	0.38	0.27	0.84	0.28	0.26	1.01	0.33	0.31	1.22	0.30	0.25	0.80
	ANGULAR	5.11	4.63	17.44	4.34	3.08	11.52	4.65	3.97	16.85	5.63	3.75	15.83	6.34	4.74	17.60
8	LINEAR	0.34	0.24	0.77	0.38	0.33	1.24	0.25	0.25	1.04	0.31	0.38	1.34	0.31	0.23	0.81
	ANGULAR	5.13	3.18	11.00	4.95	3.75	13.77	6.57	4.83	16.26	4.15	2.57	9.03	6.18	4.33	13.99
9	LINEAR	0.63	0.47	1.72	0.35	0.22	0.66	0.42	0.35	1.31	0.31	0.22	0.73	0.39	0.30	1.34
	ANGULAR	7.93	7.83	29.01	5.80	4.33	14.41	4.53	3.30	13.87	7.02	3.80	12.26	6.38	4.65	15.99
10	LINEAR	0.33	0.22	0.75	0.36	0.26	1.02	0.33	0.34	1.52	0.35	0.28	0.96	0.44	0.42	1.37
	ANGULAR	5.60	3.66	12.32	4.74	4.11	17.79	4.77	5.08	19.31	4.90	3.38	11.90	7.38	4.84	19.08
N=22																

TABLE 4

$\overline{X}$ OF ANGULAR DISCREPANCIES OF EACH

FACULTY BY TOOTH PAIR IN DEGREES

Arch	Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10	Total $\overline{X}$
UPPER ARCH	1-1	10.30	13.29	7.42	6.46	7.16	4.80	2.95	6.27	7.76	8.69	7.56
	1-2	7.14	2.96	6.40	3.56	7.10	4.52	4.12	3.32	3.51	3.61	4.62
	2-1	5.87	5.45	4.32	4.04	4.93	6.91	4.02	4.92	5.32	6.16	5.19
	2-3	6.97	4.76	7.72	3.13	8.33	7.41	6.60	6.01	6.88	4.32	6.21
	3-2	6.61	5.54	7.09	4.08	8.89	1.96	6.96	9.43	3.73	6.14	6.04
	3-4	8.24	4.14	3.95	4.87	13.17	5.95	5.58	4.44	7.12	11.61	6.90
	4-3	8.20	4.95	5.49	5.58	7.05	5.53	6.52	7.93	5.39	5.98	6.26
	4-5	4.76	2.21	3.64	2.62	6.23	3.25	1.91	5.23	5.89	5.64	4.13
	5-4	6.03	5.87	5.27	5.36	8.31	3.18	7.69	7.30	5.56	4.13	5.87
	5-6	3.95	5.52	3.84	3.86	3.24	3.56	3.94	6.05	5.48	7.69	4.71
	6-5	2.90	3.72	8.34	6.80	9.93	3.99	3.32	7.57	8.50	6.49	6.15
LOWER ARCH	1-1	4.11	3.37	3.72	4.74	3.11	2.14	2.93	3.85	5.94	2.35	3.62
	1-2	5.33	2.98	2.27	3.09	3.21	4.13	4.66	4.52	7.12	2.74	4.00
	2-1	5.92	3.56	4.28	2.32	7.12	6.44	2.10	3.29	5.66	4.35	4.50
	2-3	5.22	5.58	3.68	7.77	4.31	4.05	5.78	7.24	11.63	4.62	5.98
	3-2	6.56	5.55	4.79	5.38	6.08	2.48	5.83	4.25	9.30	3.48	5.37
	3-4	5.72	3.00	5.99	9.70	6.63	4.66	7.52	3.65	9.10	6.61	6.25
	4-3	11.16	7.01	9.32	6.28	6.97	5.55	7.77	5.14	7.83	6.10	7.31
	4-5	4.29	3.82	8.44	7.02	7.00	4.11	7.89	4.39	7.59	5.69	6.02
	5-4	4.24	2.28	8.39	5.20	7.56	4.21	4.45	4.82	3.26	5.63	5.00
	5-6	4.15	7.99	6.77	8.46	4.72	3.86	7.73	6.19	4.47	9.95	5.93
	6-5	4.80	3.54	5.34	2.24	7.65	5.90	4.44	2.92	2.32	3.51	4.26

N=5

TABLE 5

$\overline{X}$ OF VERTICAL DISCREPANCIES BY TOOTH PAIR IN mm

UPPER ARCH 6 TO 6

Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10	Total $\overline{X}$
1-1	0.27	0.24	0.27	0.11	0.14	0.33	0.06	0.18	0.13	0.21	0.19
1-2	0.57	0.44	0.24	0.44	0.46	0.40	0.21	0.21	0.28	0.55	0.37
2-1	0.67	0.57	0.60	0.51	0.31	0.39	0.16	0.36	0.48	0.33	0.44
2-3	0.54	0.18	0.16	0.23	0.26	0.33	0.23	0.18	0.58	0.29	0.30
3-2	0.66	0.63	0.27	0.30	0.17	0.13	0.33	0.12	0.41	0.30	0.33
3-4	0.52	0.39	0.28	0.44	0.42	0.46	0.50	0.45	0.54	0.49	0.44
4-3	0.39	0.60	0.40	0.19	0.47	0.19	0.31	0.37	0.21	0.20	0.33
4-5	0.37	0.45	0.19	0.35	0.48	0.44	0.52	0.55	0.33	0.36	0.40
5-4	0.24	0.30	0.24	0.34	0.28	0.31	0.35	0.69	0.44	0.23	0.34
5-6	0.62	0.75	0.30	0.61	0.63	0.87	0.82	0.82	0.63	0.99	0.70
6-5	0.55	0.30	0.28	0.36	0.63	0.65	0.32	0.57	0.38	0.28	0.43

LOWER ARCH 6 TO 6

Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10	Total $\overline{X}$
1-1	0.22	0.22	0.13	0.16	0.11	0.19	0.19	0.22	0.37	0.31	0.21
1-2	0.19	0.06	0.06	0.21	0.26	0.19	0.14	0.14	0.25	0.15	0.16
2-1	0.19	0.17	0.11	0.22	0.26	0.14	0.17	0.23	0.42	0.19	0.21
2-3	0.31	0.41	0.28	0.29	0.27	0.14	0.29	0.18	0.82	0.30	0.33
3-2	0.31	0.26	0.42	0.27	0.40	0.50	0.31	0.21	0.69	0.47	0.38
3-4	0.33	0.11	0.18	0.34	0.22	0.34	0.19	0.28	0.68	0.31	0.29
4-3	0.33	0.44	0.29	0.39	0.34	0.34	0.37	0.37	0.37	0.48	0.37
4-5	0.37	0.39	0.35	0.46	0.37	0.30	0.22	0.26	0.28	0.51	0.35
5-4	0.31	0.30	0.34	0.34	0.47	0.33	0.45	0.39	0.38	0.44	0.37
5-6	0.18	0.30	0.20	0.45	0.21	0.24	0.43	0.13	0.34	0.40	0.28
6-5	0.22	0.23	0.23	0.20	0.34	0.31	0.43	0.06	0.23	0.18	0.21

N=5

TABLE 6

$\overline{X}$ AND S.D. OF THE ANGULAR DISCREPANCIES BY MODELS

Arch	Tooth Pair	MEAN $\bar{X}$ MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	S.D. MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
UPPER ARCH	1-1	7.61	9.35	5.37	6.16	9.30	4.79	5.25	2.98	4.65	4.85
	1-2	4.99	4.25	4.24	4.04	4.60	2.82	3.08	3.21	2.45	3.11
	2-1	2.72	3.66	8.00	5.92	5.67	2.23	2.62	6.19	4.10	3.60
	2-3	5.11	3.03	6.08	5.70	11.15	3.53	2.30	3.99	3.06	6.54
	3-2	4.37	5.00	5.80	7.22	7.82	4.09	3.10	5.27	2.75	4.25
	3-4	7.41	6.11	6.40	6.40	8.21	5.66	3.71	5.26	3.90	5.48
	4-3	7.14	5.83	7.09	4.42	6.83	5.25	4.41	3.84	1.98	4.57
	4-5	5.41	3.26	4.04	3.79	4.19	4.88	2.06	3.01	4.36	1.40
	5-4	5.99	4.69	5.35	3.09	10.23	4.01	3.79	3.08	2.57	5.34
	5-6	5.22	3.09	5.56	4.76	4.93	4.04	2.14	5.59	2.94	4.12
	6-5	5.09	6.90	4.17	6.31	8.30	2.58	5.19	1.92	4.29	5.26
LOWER ARCH	1-1	3.31	3.86	2.90	5.01	3.05	3.44	3.21	1.67	3.91	1.35
	1-2	2.88	3.44	3.99	5.51	4.20	1.61	3.37	2.97	3.47	4.02
	2-1	3.63	8.86	2.66	4.14	3.24	3.01	6.74	1.52	2.52	2.64
	2-3	6.66	3.94	7.19	4.98	7.17	8.19	3.31	5.54	4.27	4.79
	3-2	6.04	5.46	4.49	4.66	6.19	4.41	3.35	3.30	3.38	4.57
	3-4	7.42	5.95	6.62	4.67	6.63	5.88	4.13	3.10	2.95	5.50
	4-3	6.86	7.15	6.90	9.07	6.58	4.00	5.74	4.44	3.37	3.84
	4-5	14.34	2.97	4.14	4.35	4.32	6.61	2.06	0.18	2.54	3.71
	5-4	6.48	4.03	4.18	4.89	5.44	4.23	3.76	0.22	3.66	4.14
	5-6	9.02	4.30	6.17	4.93	5.23	4.91	2.63	0.14	4.20	6.22
	6-5	3.54	5.27	2.20	6.30	4.03	2.40	3.64	0.13	5.44	3.89

N=50

TABLE 7

$\overline{X}$ AND S.D. OF THE VERTICAL DISCREPANCIES BY MODELS.

	Tooth Pair	Mean $\bar{X}$ Model 1	Model 2	Model 3	Model 4	Model 5	S.D. Model 1	Model 2	Model 3	Model 4	Model 5
UPPER ARCH	1-1	0.19	0.24	0.14	0.19	0.20	0.12	0.13	0.14	0.15	0.20
	1-2	0.33	0.44	0.27	0.56	0.30	0.24	0.34	0.24	0.28	0.24
	2-1	0.44	0.51	0.44	0.57	0.24	0.31	0.23	0.20	0.38	0.18
	2-3	0.30	0.34	0.26	0.24	0.36	0.21	0.27	0.24	0.24	0.36
	3-2	0.20	0.29	0.37	0.41	0.38	0.23	0.28	0.30	0.37	0.25
	3-4	0.30	0.46	0.44	0.49	0.54	0.19	0.27	0.38	0.21	0.32
	4-3	0.37	0.28	0.41	0.35	0.25	0.24	0.24	0.37	0.33	0.18
	4-5	0.43	0.62	0.32	0.35	0.32	0.26	0.32	0.26	0.26	0.19
	5-4	0.42	0.47	0.23	0.31	0.28	0.30	0.38	0.18	0.27	0.18
	5-6	0.84	0.38	0.96	0.81	0.44	0.32	0.25	0.30	0.45	0.32
	6-5	0.62	0.47	0.54	0.25	0.28	0.43	0.33	0.32	0.35	0.12

	Tooth Pair	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
LOWER ARCH	1-1	0.30	0.20	0.18	0.18	0.20	0.23	0.18	0.11	0.16	0.14
	1-2	0.16	0.17	0.11	0.18	0.20	0.23	0.09	0.09	0.14	0.24
	2-1	0.26	0.30	0.19	0.17	0.13	0.20	0.17	0.10	0.16	0.08
	2-3	0.33	0.36	0.32	0.31	0.32	0.54	0.26	0.26	0.25	0.24
	3-2	0.30	0.24	0.29	0.26	0.82	0.25	0.13	0.20	0.20	0.31
	3-4	0.49	0.23	0.27	0.25	0.24	0.47	0.20	0.26	0.23	0.21
	4-3	0.32	0.20	0.24	0.40	0.21	0.26	0.12	0.13	0.18	0.34
	4-5	0.34	0.62	0.20	0.23	0.36	0.18	0.17	0.18	0.19	0.20
	5-4	0.50	0.35	0.27	0.32	0.44	0.29	0.11	0.22	0.26	0.38
	5-6	0.36	0.29	0.16	0.31	0.31	0.25	0.24	0.14	0.23	0.15
	6-5	0.23	0.29	0.19	0.12	0.25	0.17	0.17	0.13	0.18	0.17

N=50

CHAPTER V

DISCUSSION

This research project was conducted to evaluate the accuracy of bracket placement in the preadjusted orthodontic appliance. The objective of all these appliances is to produce desired tooth movement with a minimum amount of wire adjustments.

Difficulties were found in placing the orthodontic brackets at the correct height and the correct angulation, apparently the operator had far greater difficulty judging angles than heights as shows table 1.

Towards the end of the treatment, the teeth must be brought as close as possible to their final and functional positions before debanding. That necessitates a perfect alignment of the marginal ridges, contact points and roots of the teeth. When factors such as error in bracket placement tooth irregularities, variations in tooth morphology are involved, it is difficult to achieve accurately these goals with the preadjusted orthodontic appliance.

Table No. 1 showed a range of 1.80 mm. for vertical discrepancy but this was at the bracket edge, if we consider the width of the bracket versus the width of the tooth the vertical discrepancy at the tooth will be about the double. A range of 29.10 degrees for angular discrepancy was observed, which is more than the most tip placed in a preadjusted appliance (Roth 13^{o}), this indicates that there is a great clinical significance since that amount of error in bracket placement affects the proper tooth position.

The mean angular discrepancy of 5.54 degrees plus the standard deviation of 4.32 degrees means that a bracket 10 degrees different from its neighbour would occur with the same frecuency as a bracket placement in perfect alignment.

It is impossible to look at the tooth from the buccal and the occlusal at the same time as well as routinelly visualize where the roots are in the alveolar bone.

The fact that the majority of faculty were so similar in the results indicates a basic human limitation in direct placement of the brackets in the mouth.

The clinical implication of this malposition are the following:

- Unestable tooth positions.
- Food impaction due to marginal ridges discrepancies.
- Failure to establish the very specific occlusal schema of cuspid rise or mutually protected occlusion, which is necessary to establish proper neuromuscular function and protect the teeth from wear and the muscles from injury.

Table No. 2 indicates that there was a significant difference in bracket position among faculties, but all of them had a considerable amount of error, specifically in angular measurements.

The ten faculty members employed in this study were considered the average orthodontist, and according to the results of this research project, we can deduce that it will not be possible that an operator can place the orthodontic brackets in a patient's mouth with a hundred percent of accuracy.

Faculty No. 3 used a "Boone Gauge" as an aid for better bracket placement. Table No. 2 and 5 show significant difference from the other faculties. Faculty No. 3 had less vertical bracket displacement than the others. But a difference of 0.12 mm. from the other faculties does not mean that there is a clinical significant difference.

Table No.3 indicates that Model No. 2 had a significant less angular discrepancy than Model No.5, the reason for this, is that Model No. 5 has a lower right first bicuspid severly malposed (lingually positioned), the crowding in the area and the size of the clinical crown of that specific tooth, makes it impossible to correctly place the bracket. Another explanation for this fact, is that Model No. 2 has bigger clinical crowns, not severly rotated teeth, having less difficulties for the operator in placing the orthodontic brackets. There is not any factor that has to do with the type of malocclusion.

There is no correlation among types of malocclusion, which makes it more difficult or easier placement of the brackets. It has to do more with the skill of the operator, tooth morphology, size of clinical crowns, and malposition of the tooth in the dental arch. However it should be considered that there are cases like a Class II Division II, where the upper anteriors interfere with the placement of the brackets in the lower anteriors, or when the operator has to compromise and place the bracket more gingivally because it interferes with the occlusion, such cases with deep overbite or long cuspal heights on posterior teeth.

Any effect of bracket interference was excluded in this study, the actual clinical accuracy of bracket positioning on the posterior teeth would be much worst than was showing on the study, specifically for the linear measurements.

In a case like Model No. 5, with a severly malposed tooth and it is decided to place the preadjusted appliance, which has the total amount of adjustments prefixed into the brackets, the only way to correct the angular and vertical position of the slot of the bracket is to bend the arch wire. In subsequent stages, the heavier wires are needed in order to progressively fully express the adjustments built into the bracket must also carry these compensating bends. That introduces additional variable to the appliance manipulation which relates to the difficulty of repeating certain bends from wire to wire.

Table No. 4 and 5 indicate that the lower anterior teeth presented less discrepancy in placing the brackets, in both, angular and vertical discrepancies. It seems that it is easier for the operator to visualize the long axis of the lower incisors and has as a reference the incisal edges of the tooth to place it appropiately and at the correct height, furthermore the brackets of the lower incisors do not have any angulation built in to the bracket.

The teeth that showed most angular discrepancy were the upper anteriors and the upper and lower cuspids. It appears that the operators have different criteria in root angulation and it is difficult for them to judge angles, since the brackets for the upper anteriors and the cuspids have the most angulation built in the bracket, when the preadjusted appliance is used.

For the vertical discrepancies the teeth that presented the most difficulty in placing the brackets were the upper second bicuspids, probably due to the clinical crown of the second bicuspid. Some times it is too small and does not allow placement of the bracket more gingivally. Another reason is because the upper molar brackets have the headgear tube occlusally and it appears that the operator placed the brackets of the upper second bicuspid more occlusally probably because he takes as a reference the molar tube.

There was less vertical bracket discrepancy in the lower first and second bicuspids, but again in this research project bracket interference was not considered. Therefore, the vertical discrepancies in bracket position for the lower bicuspids would most certainly shown more severe results.

Table No. 5 shows a significant greater difference on vertical discrepancies between the upper first molar and the second bicuspid on the right side than the upper first molar and the second bicuspid on the left side. It seems that the operator had more difficulty in placing the brackets on the left side than in the right one. More obvious in the upper arch than in the lower arch. The reason for this fact is probably because it is harder for the operator to visualize and judge the correct height of the brackets on the opposite of the patient.

It should not be interpreted from this study that achievement of acceptable orthodontic results is impossible with straight wire therapy. With proper wire bending or improving bracket position, an excellent result can certainly be achieved.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate vertical and angular bracket position utilizing a preadjusted orthodontic appliance. Positional discrepancies were measured from a horizontal reference line, variations were evaluated with respect to the classification of malocclusion, specific tooth type and intra/inter operator differences.

Ten faculty members from the Orthodontic Department at Loyola University were employed in this study. Each faculty placed pre-adjusted brackets on five non-orthodontic patient models with different type of malocclusions.

A total of 50 cases served as the population of the study. Which were mounted on a mannequin to simulate the mouth of the patient.

Photographs were taken to measure the vertical and angular discrepancies in bracket position, the measurements were taken by tooth pairs, the vertical measurements were calculated from a horizontal reference line, and the angular measurements were calculated from the angle that is formed by each bracket to its neighbour.

From the results of the statistical analysis of variance a mean of 0.34 mm. for the vertical discrepancies was found and a mean of 5.54 degrees for the angular discrepancies. Apparently the operator had greater difficulty judging angles than heights.

Accurate placement of an appliance is crucial for excellent treatment results, regardless of whether or not the appliance is preadjusted. However, correct placement is probably even more important in the preadjusted appliance, since the natural tendency is to place an unadjusted wire.

Tooth - position errors created by attachment misplacement for built-in tip have the potential to be much more significant. The limited space between adjacent roots allows a very small margin or error for root placement. One primary objective of all orthodontic treatment is to ensure a regular bone thickness between parallel roots. Attachment misplacement that creates an alteration in the designed tip will jeopardize this objective.

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APPENDIX

APPENDIX A

S.D. OF ANGULAR DISCREPANCIES BY TOOTH PAIR.

	Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10
UPPER ARCH	1-1	4.06	3.48	4.69	3.63	5.07	3.96	1:37	2.49	4.09	6.75
	1-2	3.13	2.85	3.04	2.91	2.66	2.00	2.18	2.32	1.80	3.74
	2-1	8.54	5.68	4.12	3.33	3.76	5.67	2.60	2.17	3.59	2.95
	2-3	4.88	5.81	5.62	3.46	9.35	2.51	5.26	2.53	3.45	3.39
	3-2	3.30	2.45	3.59	2.31	4.29	1.36	1.65	5.39	1.60	7.14
	3-4	2.51	1.96	2.89	4.05	5.07	4.27	2.03	2.90	6.40	5.18
	4-3	5.12	2.79	5.82	2.46	4.73	0.97	6.34	3.03	5.23	4.47
	4-5	2.89	1.83	2.00	2.46	5.16	2.71	0.99	4.76	4.42	3.03
	5-4	1.55	3.50	4.81	4.47	6.60	2.46	6.76	6.19	2.68	3.65
	5-6	3.04	4.03	2.59	1.91	2.72	1.25	4.49	3.75	5.37	7.34
	6-5	1.90	2.20	3.51	2.15	6.80	3.82	2.43	4.78	4.26	3.11

	Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10
LOWER ARCH	1-1	2.85	2.83	0.61	2.83	4.36	2.03	2.51	3.56	3.78	2.58
	1-2	3.78	1.08	1.54	3.32	2.27	1.59	4.00	3.18	6.11	0.61
	2-1	8.70	3.35	1.08	1.11	6.08	4.70	1.90	2.72	4.94	1.59
	2-3	3.84	4.04	3.34	6.98	2.46	3.10	5.87	5.60	10.74	2.69
	3-1	4.69	5.63	2.30	2.53	3.97	1.78	3.48	2.93	4.36	3.08
	3-4	6.00	2.86	6.24	3.40	2.49	2.23	2.51	2.20	7.54	4.34
	4-3	1.27	4.21	6.17	4.25	3.14	4.40	6.00	2.04	4.99	3.44
	4-5	4.79	2.87	9.32	4.69	7.87	4.00	5.92	4.30	8.68	4.08
	5-4	3.98	1.63	2.27	1.59	4.60	2.69	2.36	4.68	0.95	6.05
	5-6	6.09	7.86	6.57	5.02	2.74	2.85	4.97	6.10	3.46	2.57
	6-5	3.38	1.05	5.20	1.31	7.55	4.25	3.31	1.56	1.13	3.35

N=5

APPENDIX B

S.D. OF VERTICAL DISCREPANCIES BY TOOTH PAIR.

	Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10
UPPER ARCH	1-1	0.13	0.19	0.18	0.07	0.14	0.16	0.01	0.19	0.11	0.10
	1-2	0.21	0.30	0.20	0.30	0.36	0.26	0.18	0.11	0.25	0.42
	2-1	0.52	0.31	0.31	0.21	0.11	0.28	0.10	0.10	0.21	0.20
	2-3	0.42	0.17	0.12	0.16	0.19	0.18	0.34	0.19	0.24	0.25
	3-2	0.38	0.41	0.26	0.22	0.05	0.14	0.24	0.12	0.16	0.28
	3-4	0.25	0.36	0.22	0.25	0.29	0.22	0.26	0.28	0.53	0.20
	4-3	0.14	0.44	0.19	0.14	0.47	0.13	0.22	0.27	0.14	0.24
	4-5	0.23	0.11	0.21	0.36	0.41	0.40	0.13	0.32	0.13	0.29
	5-4	0.19	0.32	0.21	0.25	0.17	0.18	0.33	0.45	0.29	0.16
	5-6	0.38	0.57	0.22	0.40	0.34	0.21	0.40	0.46	0.51	0.35
	6-5	0.19	0.17	0.28	0.29	0.60	0.53	0.34	0.42	0.23	0.13

	Tooth Pair	Faculty 1	Faculty 2	Faculty 3	Faculty 4	Faculty 5	Faculty 6	Faculty 7	Faculty 8	Faculty 9	Faculty 10
LOWER ARCH	1-1	0.21	0.10	0.12	0.10	0.14	0.16	0.11	0.16	0.17	0.29
	1-2	0.13	0.03	0.03	0.13	0.29	0.14	0.15	0.14	0.34	0.05
	2-1	0.06	0.05	0.06	0.13	0.15	0.17	0.21	0.12	0.25	0.14
	2-3	0.25	0.24	0.20	0.31	0.27	0.15	0.33	0.14	0.56	0.20
	3-2	0.27	0.22	0.36	0.25	0.32	0.42	0.18	0.13	0.40	0.40
	3-4	0.26	0.09	0.09	0.31	0.07	0.16	0.19	0.26	0.65	0.27
	4-3	0.10	0.26	0.24	0.44	0.24	0.24	0.27	0.17	0.33	0.52
	4-5	0.27	0.33	0.27	0.24	0.17	0.16	0.21	0.20	0.20	0.26
	5-4	0.28	0.24	0.23	0.18	0.31	0.18	0.28	0.26	0.29	0.52
	5-6	0.16	0.17	0.16	0.31	0.15	0.19	0.20	0.09	0.27	0.22
	6-5	0.12	0.22	0.20	0.16	0.22	0.16	0.19	0.05	0.21	0.03

N=5

APPROVAL SHEET

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

12/9/87
Date

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