The Design of an Adjustable Orthodontic Bracket

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Loyola University Chicago

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THE DESIGN OF AN ADJUSTABLE ORTHODONTIC BRACKET

by

Stephanos Karakussoglu, D.D.S.

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DEDICATION

To my wife, Dora for her love, understanding and for having successfully assumed the responsibilities of our family during my studies in the United States. She and my daughter, Christina, have been the inspiration for my success.
To my sister, Angeliki, my parents and my brother.
I would like to gratefully acknowledge all those people who have aided in making this project possible. I am indebted to Dr. Lewis Klapper and Dr. James Sandrik for encouragement and advice over this period to devote valuable time on the design of the adjustable bracket. I am indebted to the members of the committee, Dr. Lewis Klapper, Dr. James Sandrik and Dr. Andrew Chludzinski for their invaluable help in the completion of this study. I gratefully acknowledge my friend, Dr. Efstathios Marinakis, for his guiding ideas and assistance which was continuous during this work.

My sincere appreciation is extended to all of my teachers and faculty members who guided me during my orthodontic education.

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esteemed advice and the motivation for pursuing and accomplishing the training in orthodontics.

Gratitude must be acknowledged to Bernie Ciamarichello, whose patience and efficiency in typing the manuscript have been remarkable.
VITA

The writer of this thesis, Stephanos Karakussoglu, was born on December 27, 1953 in the town of Orestias in Greece. He was the youngest in a family of three children.

His elementary education and the first two years of his secondary education were obtained in the public schools in Orestias. He continued his secondary education at the 4th public high school Thessaloniki, Greece, where he graduated in 1972.

In October, 1972, he entered the Dental School, Athens University, for a five year program in dentistry and he graduated in 1977.

In November, 1977, he started practicing General Dentistry as a private practitioner for almost two years.

On December 25, 1977, he married Dora Ioannidis, also practicing dentistry and on January 20, 1979, their daughter Christina was born.

In July, 1979, he entered Loyola University School of Dentistry for a two year post-graduate course in Orthodontics, leading to a certificate of specialty and a Masters of Science in Oral Biology.
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CHAPTER I

INTRODUCTION

Among the fixed orthodontic appliances, the "edgewise" has been the most efficient mechanism in accomplishing accurately the various tooth movements which are necessary for the orthodontic treatment. Its function is basically dependent on the bending of the arch wires, which engaged into the bracket slots, produce the desired tooth movements. Since the very first presentation of this mechanism Angle, in 1928, advocated the placement of the brackets on the teeth in an angulated position in order to eliminate some wire bending. Later, when the treatment demands to accomplish detailed tooth movements became greater, the wire bending was even more complicated and difficult. Holdaway, for this reason, used the bracket angulation more extensively than Angle, in order to minimize the second order bends of the wire (vertical bends for mesiodistal uprighting or the tooth) and Jarabak used brackets with torqued slots in order to eliminate the third order bends (twists along the arch wire for the buccolingual or labiolingual axial uprighting). Recently, Andrews (1970)
introduced the Straight Wire Appliance (S.W.A.), which theoretically eliminates all the wire bending (first, second and third order bends). That appliance consisted of brackets which were preadjusted in all the possible dimensions. The preadjustments were such as to bring the teeth to "ideal" positions when unbent wires were fully engaged into the slots. The "ideal" positions in average were determined by studying the "ideal" occlusions of 120 persons never having received orthodontic treatment.

Clinically, the S.W.A. did not eliminate the wire bending because the patients vary as far as tooth morphology and malocclusion are concerned and their variations from the S.W.A. average must be compensated by properly adjusting the arch wires.

The fact that compensating wire bending is necessary when the S.W.A.'s are used, indicates that in order to completely avoid the wire bending, the preadjustments of the brackets must be individualized for each one patient. That necessitates the existence of a very large number of series of preadjusted brackets prescribed for each specific case and its treatment requirements. To make available these series of brackets is neither practical nor possible because most of the variables which will determine the necessary individualizations can not be realized before the treatment has been started.

These problems lead to the idea of having a bracket
which could be individually adjusted for each tooth in every malocclusion. That would satisfy the need for appliance adjustability in order to achieve individualization without bending the arch wires. It would also accomplish incremental tooth movements without being necessary to change progressively the arch wires.

In this project, such a bracket will be presented which fulfills all the basic principles of the edgewise mechanism and it functions as an adjustable bracket. In Chapter III, Materials, the adjustable bracket will be described in detail. In specific drawings, it will be presented as it is envisioned from different aspects and in cross sections. In Chapter IV, Results, the function of the bracket will be explained and in the Discussion, its clinical application will be compared to the standard and preadjusted appliances.
CHAPTER II

REVIEW OF LITERATURE

History tells us\textsuperscript{42} that orthodontics has been practiced for more than three centuries. During this period of time, a great variety of orthodontic appliances have been developed and used. In the literature the first description of an orthodontic appliance was given in the book "Le Chirurgien Dentiste" written in 1723 by the French physician Pierre Fauchard and published in 1728\textsuperscript{42}. This appliance did not originate with him, but it had been in use for some time. Its main function was to expand the dental arches and fit all the teeth into the form of an "ideal" arch. That was accomplished by tying into the mouth a metal band, usually made of gold or silver with gold threads passed around the teeth through holes, suitably placed on the band\textsuperscript{34,42}. The metal band, according to the case could be used as a single piece or in segments, placed either buccally or lingually\textsuperscript{42}. The force applied by the threads on the malposed teeth accomplished a simple tipping or uprighting tooth movement, with no control on the roots. That was an elemental movement which can take place when a
force is applied to the tooth crown and the tooth is free to tip any direction around a horizontal axis. That device, which was described by Fauchard, is considered to be the first orthodontic regulating appliance. It was modified later on by Bernard Bourdet, in 1757. He explained the use of his appliance for correcting orthodontic irregularities of teeth. He also advised extractions of teeth, usually premolars, in order for some arches to be aligned in a more regular form.

Since that beginning, it is possible to follow in the literature, how the various orthodontic appliances were mechanically advanced, in response to the improving ideas of treatment, and also understand the influence of each mechanical improvement on the practice of orthodontics. In the period following Pierre Fauchard's contributions, until 1900, all the appliances which were introduced were continuously improved in terms of their stability in the mouth. However, they were not capable of moving the roots of the teeth, but they could only align the crowns. So any malposed tooth was simply tipped not carried to the correct position. In this fashion, in 1842, the vulcanite plate appeared, as used by Harris. That was an appliance similar to the one described by Fauchard, but it provided more stability in the mouth. That was accomplished by attaching the labial expansion band to a lingual vulcanite plate. Like all the other plates this appliance, even though more
stable than the labial band described by Fauchard, was lacking sufficient stability in the mouth and was painful to the patients.

The next most outstanding developments were the introduction into orthodontics of tooth bands by Schange', in 1841, and the dental cement for immovably securing bands to teeth by Magil in about 1871. When bands came into use, it became possible to securely attach the appliances in the mouth. At that time the labial band was discarded in favor of the labial arch wire. Dr. Angle was the master of the expansion arch wire and in his expansion "E" arch (1900) (Figure 1) it reached its highest development. The wire used for the construction of the expansion arch was shaped into an "ideal" arch form for every patient. Its ends were threaded and fixed to the anchor molar bands. These screw-ends of the wire which were used for the first time by Evans, in 1854, made it possible to accommodate desired changes in the length of the arch wire. Again, the desired tooth movements were produced by using ligatures to pull the malposed teeth towards the arch wire. In reaction to that, a force was transmitted to the molars through the arch wire. That force tended to displace the molar teeth bodily. The molar resistance to that movement provided the anchorage (stationary) for moving the rest of the teeth.

The concept of stationary anchorage was realized in its true form by Dr. Angle in 1887\textsuperscript{34}, when he used the
traction screw. That was a device for tipping the anterior teeth backwards in Class II, division I malocclusions. It was accomplished by utilizing the molars as a resistance source, as they were pulled against the alveolar bone bodily, in an upright position. Dwinelle\textsuperscript{42} in 1849 used the jack-screw to move teeth. This method proved to be a very important manner of delivering force in orthodontic mechanisms. It is still being used in connection with various types of expansion appliances, but those appliances delivering forces by using screws were largely abandoned, in about 1900. By that time, the concept of moving the teeth on one jaw by using certain teeth on the other (intermaxillary anchorage) for resistance, was introduced by Baker.

Early in this century when the controversy over extractions in orthodontic treatment appeared in the literature, the era of searching for a better appliance began in earnest. It was realized that the appliances should be able to control root movements as well as crown tipping. The guiding concept was that normal and stable occlusion could only be obtained when proper axial inclination of the teeth was accomplished\textsuperscript{5}. Furthermore, when normal occlusion is to be obtained, both roots and crowns must be supported by an appliance until the remodeling of bone is complete\textsuperscript{12}. That matter actually necessitated the use of a rigid orthodontic attachment to
the teeth. Because the mechanical requirements for root movement, or simultaneous root and crown movement (bodily movement) are met only when a "non-pivoting orthodontic attachment" is used. As a response to these demands, the "working retainer or pin and tube" appliance was introduced by Dr. Angle in 1909. The working retainer was designed for the purpose of stabilizing the teeth in their positions after the completion of the active treatment or for slightly moving the roots of the upper anterior teeth forward. Dr. Angle believed that a gentle force on the roots of the incisor teeth for mesial movement would stimulate cellular activity for bone growth. He also believed that the tendency for moving forward the roots of the anterior teeth would keep the molars in good corrected Class I relation.

In 1911, Dr. Angle modified the "working retainer" to the more extensively used device, known as the "pin and tube appliance" (Figure 2). It consisted of small tubes soldered to tooth bands and round arch wires with soldred small pins which could be inserted into the tubes. The technique of constructing this appliance was difficult requiring the best efforts of even the most skillful operator. It involved the following steps: soldering of the tube on bands, bending of the arch wire and soldering of the pins on the wire. The position of the tubes was such, that when the bands were cemented on the teeth, they were
approximately parallel to the tooth long axis. The pins were positioned exactly at the point where the labial arch, after being properly shaped, touched the vertical tubes. When the arch wire was passive, the inclination of the pins to the respective tubes was indicative of the expected movement. When the pins were inserted into the tubes, they accordingly influenced the total position of the teeth, resulting in bodily tooth movement or pure root movement in any direction. Finally, the teeth were brought to the proper position by moving and resoldering the pins and/or reshaping the labial arch wire. The results obtained by the use of this appliance were better as far as occlusion and axial inclination of the teeth were concerned, but by using it some of the principles of the "E" arch were compromised. The "E" arch was always shaped into an "ideal" arch form, while, with the new appliance, a great deal of wire bending became necessary during the treatment. In addition, the "pin and tube" appliance was never adequate to treat all the varieties of malocclusions. This is why the expansion arch was still very often used.

Mainly because of the difficulties in the manipulation of the pin and tube appliance, many confusing modifications eventually arose in an effort to maintain the advantages, and overcome the difficulties of constructing this mechanism.

In 1916, Dr. Angle introduced his new mechanism the
"ribbon arch". It was an advance beyond what had already been produced. Compared to the "pin and tube" appliance, the "ribbon arch" had the advantage of easier manipulation and better directional force control. The new mechanism, utilized the bracket attachment to replace the tubes and pins used previously. These brackets had the open wall of the slot occlusally and the flat ribbon arch was inserted or withdrawn accordingly with the wider dimension against the labial surface of the teeth. With this innovation it was no longer necessary to resolder the pins along the wire in order to move a tooth to a certain position. With the "ribbon arch" mechanism the teeth carrying the brackets could slide along the arch wire towards the desired positions in response to a certain pressure. This arrangement of the new mechanism preserved the ability of absolute root control in most of the desired directions. It provided a high degree of stationary anchorage and the possibility for bodily movement of the anterior teeth labiolingually and of the posterior teeth buccolingually\textsuperscript{34}. In contrast, the control provided for tipping movements was very poor. Also, the ribbon arch was very weak in accomplishing any expansion, as it was made of gold. In spite of all these disadvantages, the "ribbon arch" appliance was up to this point in time the best device to satisfy the existing demands of establishing normal occlusion.
Eventually the new experience and the improved knowledge, especially about occlusion, required an even more efficient device, that would provide more possibilities to accomplish the theoretical ideal of treatment. Specifically, these demands were expressed as a need for an appliance which would more accurately control the tooth movement.

In 1928, Dr. Angle presented another new appliance called the "edgewise mechanism." This appliance consisted of arch wires, rectangular in cross section and brackets which had rectangular slots of very exact dimensions (.022 x .028 inch) cut mesiodistally on their buccal or labial surface. Ligature ties and staples were used to tighten the wires which were inserted into the brackets slots edgewise. Those ligatures were the means to control the amount of force applied on the teeth. With this mechanism the latest demands of treatment were satisfied because it became possible for the orthodontists to control accurately, all the tooth movements. Specifically, it became possible to move the teeth bodily in a mesiodistal direction by sliding them along the arch wire, tip, torque, and rotate them. Theoretically, the teeth could be moved towards their final positions, by progressively engaging into the slots a flexible wire, having the proper arch form. Furthermore if that wire had a perfect fit into the bracket slots, and all the required bends were incorporated into the wire from the beginning, the teeth would eventually be taken to the final
position where they provided the best occlusion\textsuperscript{34}.

Originally the "edgewise" brackets were used by Angle in conjunction with the ribbon arch mechanism\textsuperscript{12}. It was noticed that with the "ribbon arch" brackets, it was very difficult and inefficient to manipulate the arch wire in the premolar area. The reason was that the flat ribbon arch had to be inserted in the molar tube horizontally in a distal direction and vertically (occlusogingivally) in the brackets attached to the rest of the teeth\textsuperscript{7}. In order to overcome this shortcoming, Angle started using edgewise brackets only on the premolars and canines. In addition the ribbon arch in order to be engaged into the slots was twisted 90 degrees distal to the lateral incisor "ribbon arch" brackets. Very soon, the ribbon arch brackets were completely replaced by the "edgewise" ones and the horizontal rectangular edgewise arches took the place of the vertical flat ribbon arches.

Dr. Angle in 1928 described the design of the edgewise brackets, wires, ligatures and rotating staples; the basic components of the edgewise appliance. Since then, for many years, the design of the edgewise appliance substantially did not change. The slight improvements introduced eventually, were a result of the technological progress in the field of dental materials. For example, the German silver, used extensively for the construction of the various expansion arches, was abandoned when superior
quality alloys made of platinum and gold, with small quantities of other metals became available. Those were used for the construction of the "pin and tube", "ribbon arch" and "edgewise" appliances until 1927. At that time in Europe and later in the U.S.A. the stainless steel was introduced. Its resiliency and strength made it the most suitable material for the construction of the orthodontic appliances.

Dr. Angle, in 1928, also explained how to use and manipulate the edgewise mechanism. This included the placement of the brackets on the teeth, the proper bending of the arch wires and the ligation of them in the mouth. These procedures varied from case to case and they kept changing continuously with the experience gained in this area.

The edgewise brackets were first centered and soldered on tooth bands. Then the bands were fitted and cemented in the mouth. It was usually best to bring the brackets into the center of the labial surface of the tooth. On rotated teeth, for more efficiency, the brackets were placed towards the most prominent side of the tooth and a staple was soldered opposite to it on the band to effect the rotation. The ligatures usually were passed through the staples and over the arch wire, so that the wire was deflected into the slots. On posterior teeth, the brackets had wings properly shaped for holding the
ligatures instead of the staples.

The bending of the arch wires involved first, second and third order bends. The first order bends are those made on the horizontal plane, giving to the wire, the proper arch form. These accomplish buccolingual or labiolingual movements of the teeth, which, when round wires are used, are tipping movements. When rectangular wires are used they are translating movements. The second order bends are made perpendicular to the horizontal plane of the arch wires and produce mesiodistal rotations of the teeth about a horizontal axis (tipping). The third order bends are the twists made along the axis of ribbon or rectangular arch wires to produce torquing movements. These movements result in changing the axial inclination of the teeth in a labiolingual or buccolingual direction. Specifically, the second order bends are used to upright mesially inclined teeth, like in Class II, division I malocclusions. Jarabak mentioned\(^{22}\) that the mesiodistal uprighting can be accomplished by incorporating second order bends into the arch wire but also by altering properly, 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 mesiodistal tooth uprighting. The latter means that instead of soldering the brackets 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\(^5\). Subsequently the arch wire, engaged into the 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\(^3\textsuperscript{4}\).

Holdaway\(^2\textsuperscript{0}\), in 1952, 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 brackets 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\(^2\textsuperscript{0}\), 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\textsuperscript{21}, proposed a treatment method that used "edgewise" brackets which had third order adjustments incorporated into the brackets (torqued slots). The amount of the preadjustment varied from tooth to tooth. This feature facilitated the application of third order mechanics with straight close tolerance rectangular wires. They were used at the later stages of treatment to control the buccolinguinal or labiolinguinal 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 of the teeth with straight light round arch wires. Dr. Jarabak pointed out later, that the amount of bracket mesiodistal angulation varies according to treatment goals as far as facial esthetics, functional harmony, denture stability, cephalometric standards as well as tooth morphology. 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 degree 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 the maxillary canines and 7 degrees distal tip for mandibular canines. 

The concept of light forces was introduced in orthodontics when experimental studies gave an idea about the reaction of the periodontium to the tooth movement. It was shown that light round wires exert more physiologic forces. The response to that was a move towards the use of round wires light and resilient instead of close fitting rectangular arches. This resulted in the development of the light wire philosophies and techniques. The most popular of them has been the Begg technique based on the differential light forces theory of Storey and Smith. This technique was associated with the use of brackets which provided one point contact between arch wire and teeth. That permitted only tipping movements of the teeth unless auxiliaries were added. These auxiliaries were extra wires attached to the main arch wire and the teeth, which produced moments to upright or torque the teeth. The "Begg" brackets were similar to the ribbon arch brackets, but they were used only with light round arch wires.

The various movements of the roots needed at the different stages of treatment, were dependant on the use of auxiliary
wires, eyelets or springs. The torquing movement was the weakest point of the Begg appliance. That matter gave rise to many modifications of the original "Begg appliance" bracket. Some of them tended to add to it an "edgewise" slot and develop a combination bracket. This phenomenon of combining the edgewise principles with the principles dictated by the differential light force theories indicates that in recent years there has been a strong influence from one technique to the other. In this course of evolution, the development of the orthodontic appliances always has been a matter of understanding the demands of orthodontic treatment and a matter of interpretation of the mechanical and biological principles involved in the tooth movements.

The orthodontic bracket has been a key element in the achievement of the treatment goals and the improvements in its design were real advancements in the development of the 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\(^{28}\). The evolution of the bracket has come a long way since the first time that a bracket was introduced by Angle as a part of his "ribbon arch" mechanism. This early bracket was abandoned in favor of the "edgewise" bracket early in this century, but since 1956, Dr. Begg used it, slightly modified, in his light wire technique\(^{28}\). The original "edgewise" brackets were made from a solid block of
metal and had a slot cut horizontally across it. The basic components of it were, the base and the central stem on which the slot was cut in a mesiodistal direction. One of the designs had the outer sides of the bracket beveled from the slot to the base. That bracket was designed especially to be used on anterior teeth and it was known as open face bracket No. 1. The open face bracket No. 2 was designed for the posterior teeth and instead of being beveled it had hanging flanges or wings. The slots in both brackets were .022 inch in thickness and .028 inch in depth for the reception of metal arches which at that time were held at the same dimensions .022 x .028 inch for the rectangular and .021 inch for the round wires.

Early in 1950's, Ricketts, Steiner and Lang, thought of narrowing the dimensions of the slot size. They finally moved from the large slot .022 x .028 inch to a smaller one, standardized at .018 x .025 inch. Today, the commercially available brackets come with mainly three different slot sizes, .022 x .028 inch, .018 x .025 inch and .0185 x .030 inch (Ricketts).

The bracket known as No. 447 had rather square wings occlusally and gingivally to the groove for the reception of the ligature wire. It was made of gold alloy and because of that, it was referred to as the "soft bracket". As Terwillinger mentioned in 1951, the No. 447 bracket was very susceptible to distortion due to both wire and the
forces of mastication.

Dr. Steiner, in 1933-34, introduced some modifications to the edgewise bracket. He observed that in the original bracket, the base of the slot which normally receives the most of the strain was relatively weak and that the wings were unnecessarily large, diminishing the clearance for passing the ligatures behind them. The new design that he proposed, had the base and the side walls sufficiently strengthened to withstand any strain that could be exerted upon it by the full sized wires. The wings were diminished in size to allow full clearance for passing the ligatures and shaped in such a way as to prevent them from slipping. This bracket was carefully and accurately milled, from a solid piece of metal instead of being stamped. The slot was held to very exact dimensions .022 x .028 inch. This modified bracket known as NO. 452, "hard bracket," was very rigid and capable withstanding heavy forces. It was used with full sized arch wires. These had a perfect fit in the slots throughout the entire treatment. It was thought that a tolerance of only .0005 inch between arch wire and slot gives the best working fit. That made possible the full expression of all the bends incorporated into the full sized arch wires. However, Chapman described such an arrangement as being unphysiologic, as it deprived the teeth of freedom of movement and the supporting tissues of their functions. That matter also created the need for more wire
bending before engaging the arch wire into the slots. This situation was very soon compensated for by the use of smaller dimension arch wires.

One of the very serious shortcomings of the edgewise bracket, as it was developed so far, was the limited control over rotated teeth. Originally, whenever a tooth had to be rotated a staple was placed on the band mesially or distally to the bracket. The wire was pulled towards the staple by a ligature tie exerting in this manner a rotating moment on the tooth. This method was very difficult and lacked efficiency. Later wider brackets 0.10 inch (instead of 0.05 inch) were used in order to create a leverage between the mesial and distal end of the bracket when the wire was engaged by the ligature tie in the slot in order to rotate the teeth. That was not very practical though, when heavy wires were used, due to the reduced interbracket distance.

Paul Lewis\textsuperscript{25} in 1949, advocated the attachment of a ribbon arm to the brackets, extending mesially and/or distally from it (rotating bracket). That bracket facilitated the correction of tooth rotations and made it possible to prevent the teeth from rotating during retraction through extraction spaces. Other brackets with rotating arms were introduced by Steiner\textsuperscript{28} and some of them were designed to have a notch on each arm for better control over the mesiodistal tooth inclination. The difference between the various types of rotating brackets
related basically to the stiffness of the rotating arms. The brackets having flexible arms were suitable to be used with heavy arch wires and vice versa.28

A very important step in bracket design, was made when the "twin edgewise" bracket was introduced.35 It consisted of two single edgewise brackets manufactured on the same base. These brackets were named "siamese or twin brackets" by Dr. Swain.35 The idea appeared when two single brackets were welded on the same band at some distance from each other, so that they would be effective in rotating teeth. The twin brackets as well as the single ones carrying the rotating arms with the notches on them had the disadvantage of decreasing the interbracket span. However, they received a wide acceptance by the orthodontists who compensated for the disadvantage by using lighter wires or by incorporating loops into the wires. The "twin" brackets also come in three different widths, narrow, medium and wide, in order to be used selectively on teeth with different widths.35

Creekmore10, in 1976, made some very interesting remarks, comparing single and twin brackets. He pointed out that by increasing the interbracket width 1.5 times when single brackets are used instead of twins, the stiffness of the wire decreases 3.37 times. The clinical significance is that for the same arch wire, the single brackets will achieve 1.7 mm. leveling and 7.5 degrees torque while the
twin brackets will achieve .5 mm. leveling and 5 degrees torque only, without exceeding the elastic limits of the wire. Ricketts, et. al.\textsuperscript{29} comparing single brackets with rotating arms to the "siamese" ones, mentioned that the latter gather more advantages especially for efficient torquing, tipping and rotating movements with light wires.

Some of the original edgewise brackets that Dr. Angle designed, had a vertical slot incorporated into the base which at that time, intended to be used for passing ligatures through, to secure the arch wire\textsuperscript{28}. The potentialities of the vertical slot used in addition to the main horizontal, were brought up by the Braussard\textsuperscript{8} brothers in 1964. This feature made it possible to rotate or upright the teeth, by using various springs inserted into the vertical slot. That has been a very efficient way even to retract canines or upright them during retraction. The single edgewise bracket which carry the vertical slot for the various rotating or uprighting springs, constituted a very efficient attachment. It had all the advantages of a single bracket, and by providing the vertical slot, it was compensated for the inefficiency in rotating or tipping teeth. The use of the vertical slot on twin brackets does not add much to the efficiency of them, except that a rotating or uprighting bar could be used with it in certain occasions\textsuperscript{28}.

In 1963, Dr. Jarabak introduced the Jarabak edgewise
force control bracket. These brackets are made to be used on maxillary and mandibular six anterior teeth in combination with edgewise twin brackets .018 x .028 inch for the posterior teeth. They come in three lengths mesiodistally; .160 inch for the maxillary central incisors, .120 inch for maxillary lateral incisors and mandibular centrals and laterals and .140 inch for upper and lower canines. The Jarabak brackets resemble the single edgewise ones, but they are wider. Their horizontal slot is .017 inch wide and .038 inch deep. The incisor brackets carry a vertical slot at the distal end of them, .045 inch deep and .017 inch wide. This vertical slot is made at the expense of the central stem of the bracket and the wings but not the base. The canine brackets are similarly slotted on the mesial side and in addition, they have another vertical slot .016 x .016 inch, at the distal end of the base. The horizontal slot is cut closer the incisal edge for better torquing control by the vertical loops incorporated into the arch wires. These brackets were designed for the purpose of moving teeth under absolute control with light round wires. 

In 1963, Fogel and Magill presented a system of controlled light wire therapy, the combination technique. They tried to combine in one appliance the most significant principles of the light wire and edgewise mechanisms for both extraction and non-extraction cases. The main idea was to make an appliance resembling both the "Begg" and
"edgewise" appliance, in order to be able to retract anterior teeth with light wires using the Begg technique, and control the position of the teeth at the final stages using rectangular wires. The basic unit of their appliance is the combination bracket. This is a single unit in which the light wire and twin edgewise brackets are combined.

Later, in 1972, Fogel and Magill\textsuperscript{14} invented the light wire insert bracket which actually has been an accessory to the vertically slotted twin or single edgewise bracket. The purpose of that was to provide a non-binding, one point pivotal contact between the light round arch wires and the brackets during the initial stages of the treatment. The vertical slot of the edgewise bracket was increased in dimensions measuring $0.019 \times 0.020$ inch to accommodate the inserted accessory.

In 1967, E. Silverman and M. Cohen\textsuperscript{38} introduced the interchangeable bracket. That was a device to serve the practitioners whose technique was a combination of "Begg" and "edgewise". The idea of a combination bracket was not new, but the feature of interchangeability was introduced for the first time. The interchangeable combination bracket consisted of the receptacle made of four different widths and the bracket itself, which could be either similar to the "Begg" bracket or to the edgewise one. During the treatment and according to the stage or the type of tooth movement required, one or the other bracket members could be inserted.
into the receptacle, the only part of the assembly fixed on the tooth. In this way, this combination mechanism permitted the use of round wires with "Begg" brackets and rectangular arch wires with "edgewise" brackets interchangeably.

It has been mentioned so far, that mesiodistal bracket angulation and buccolingual or labiolingual slot angulation to tip and torque the teeth respectively, were applied by many orthodontists. They intended to minimize the wire bending and make their technique more efficient by eliminating the error, which was introduced due to the play that any smaller rectangular arch wire experiences in a larger bracket slot\textsuperscript{20}. That idea was probably the forerunner of the preadjusted appliance treatment concepts.

A preadjusted or straight wire appliance (S.W.A.) was introduced by Andrews\textsuperscript{1,2,3,4} in 1970. It does not imply a new mechanism, but it is a modified edgewise appliance. The modification is that the S.W.A. brackets 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, are 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 nonorthodontic patients with normal occlusions were studied. Some conclusions were derived concerning the positions 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":

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 angulation 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 S.W.A. 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 S.W.A. brackets which are:

1. The mesiodistal preangulation of the slots within the brackets.

2. The inclined bases.

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

The application of the S.W.A. demands the definition of the exact orientation and position of the S.W.A. brackets on each individual tooth. That involves the vertical position as well as the angular alignment of the brackets. Mistakes in placing the S.W.A. on the teeth, effect the amount of the tip, torque and in/out adjustments which are given by the brackets. Thurow mentioned\textsuperscript{41}, that two different vertical positions of a bracket, on a tooth, will cause two different buccolingual axial inclinations (torque). Meyer and Nelson\textsuperscript{27} specifically pointed out that an error of 3 mm. vertically in bracket placement on premolars can result in 15 degrees torque alteration and .04 mm. alteration in the applied in/out adjustment (Figure 3). An error, also, of bracket positioning decreases or increases the slot angulation, may result in different than expected mesiodistal axial inclination of the teeth. Dr. Andrews advocated the use of specific landmarks on the teeth for the angular and linear orientation of the S.W.A. brackets. They
are the long axis of the **clinical crown** (LACC reference line), and the midpoint of the **clinical crown** 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 incisor is 5 degrees (Figure 4). This is the angle formed between the crown axis (LACC) and a line perpendicular to occlusal plane. The crown torque measured as the angle between the same perpendicular line and a tangent to the crown at the LA reference point was 7 degrees (Figure 4). Therefore, when the S.W.A. 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 torque. When the brackets are all placed on the teeth perfectly oriented to the reference marks, also compensate for the difference in thickness between the various tooth types in every arch. That is because there are first order adjustment incorporated into the brackets, expressed as different bracket thickness for different tooth types.

The slots of the S.W.A. brackets, as Andrews explained\(^{34}\), are angulated certain 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) (Figure 5). 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 submitts\textsuperscript{3} 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 bases 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 anchorage 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 that 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 unnecessary tooth movements may be avoided. Also, with the S.W.A. technique the wire bending is minimized. This means that the teeth move along direct vector lines from the maloccluded position to the correct one, guided by the features built into the brackets. The avoiding of any excessive or round tripping movement, indicates that the consumption in anchorage may be less than any other technique\textsuperscript{2,3}.

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 cases are treated with the same appliance, but another forty per cent of those require S.W.A. extraction series brackets and arch wires slightly bent\textsuperscript{2}. The standard non-extraction S.W.A. brackets, as mentioned before, are programmed 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 have either to be moved through an extraction space or to serve as resistance source (anchorage). The S.W.A. extraction series, anticipate the need for the additional anchorage requirements and greater bodily movement of certain teeth through extraction spaces. Specifically these brackets, in addition to tip, torque and in/out features, have built in "anti-tip" and "anti-rotation". The "anti-rotation" is given by raising (buccolingually) the bracket slot at the mesial end compared to the distal, when the respective tooth is going to be moved distally (or vice versa). The "anti-rotation" is provided by properly altering the slot angulation to keep the resistance teeth (anchorage) and the retracted teeth upright. The amount of "anti-tip, anti-rotation" is proportionate to the extent of the extraction spaces².

Dr. R. Roth³⁰, whose main concern has been the gnathology as it relates to orthodontics, presented in 1975, a paper evaluating the S.W.A. after he used it for five years. He found the S.W.A. 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. The S.W.A. 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 the slots of them. With the S.W.A.'s, the desired tooth position of all the teeth are predetermined into the brackets in all three planes of space, (tip, torque, in/out).

In conclusion, according to Roth, the advantages of the S.W.A. 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.


Dr. Roth\textsuperscript{31} later on, slightly modified the S.W.A. by changing the amount of the preadjustment 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 settling or relapse of the teeth, after the active treatment, into an arrangement which is in absolute harmony functionally and esthetically.

M. Meyer and G. Nelson\textsuperscript{27}, (1978) presented an analysis of the preadjusted edgewise appliance concept. They took into consideration, basic mechanical principles involved in the function of any orthodontic appliance, in order to better understand and use the S.W.A.'s. They mentioned that in any fixed appliance the wire to bracket interaction can be described in terms of moments or "couples" of forces. In order to tip a tooth mesially or distally with a preadjusted bracket and a wire, a "couple" of forces is needed (Figure 6). This force system may be produced either by angulating the bracket on the tooth or by having the slot angulated within the bracket. Both methods have the same effect on tipping the teeth because the rotational moment that is exerted on the teeth is dependent
only on the degree that the brackets or slots are angulated and not on the method in which this angulation is produced. The same holds true for any third order preadjustments incorporated into the brackets. The action of the rectangular arch wire into a pretorqued slot is the same whether the torque is produced by inclining the base to the slot of the bracket or by torquing the slot to the face of the bracket (Figure 6). The only difference between those two situations relates to the vertical positioning of the bracket on the teeth; it does not effect the torquing movement of the teeth. For those brackets which have inclined bases for torquing, the bases will be leveled vertically when the slots are engaged to a full sized wire, while for those which have the slots torqued to the face of the brackets, the bases will not be leveled. The amount of their vertical displacement in the latter case, depends upon the degree of the incorporated torque. For that reason, the authors recommend to use the slots for orientating the brackets on the teeth, not the bases.27

Another issue discussed in the same publication, was the magnitude of each preadjustment incorporated into the S.W.A.'s. Today, in order to satisfy each practitioner's treatment goals, there are many variations of preadjustments available. They range from the preadjustment carried by the stock appliances to those that carry the desired preadjustments that each operator wants. All of these
modifications are designed to produce the best, or "ideal" result for each operator and his technique.

Generally, the preadjustments are fully expressed when the brackets are engaged to full sized arch wires. Only under that condition, may the "desired" final position of the teeth be achieved. Otherwise careful wire adjustment is needed in order to compensate for the amount of preadjustment not expressed, when the arch wires are of smaller dimensions than the slots. Smaller wires allow the expression only of a certain increment of the preadjustment. For example, in a .022 x .028 inch slot, torqued 20 degrees, a full sized arch wire will produce the desired amount of torque. A .018 x .025 inch arch wire in the same slot will produce only 8 degrees of torque according to Meyer and Nelson\textsuperscript{27}. That means that incremental movements with the S.W.A.'s can be achieved by gradually increasing the wire size while in the standard edgewise techniques, the incremental movement of the teeth are accomplished by the sequential wire adjustments.

Dr. Dellinger, in 1978\textsuperscript{11}, questioned the validity of the S.W.A. theory and he conducted a pilot study 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 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 fifty studied cases. This matter, as Dellinger commented, is clinically important and it means 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.

The orthodontic literature is overwelmed by the writings\textsuperscript{3,20,29,32,35,37} concerning methods of positioning the bands and brackets on the teeth or the brackets themselves, since the 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 had to be easy, accurate, and reproducible. Originally it was though 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\textsuperscript{5}. Later, it was recommended\textsuperscript{35} 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. to the incisal more 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 (Stoner, Lindquist)\(^3\(^5\). 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\(^2\(^9\) thought and advocated the use of the marginal ridges as the guidelines for band and bracket vertical positioning. Later when the S.W.A. concept 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, Dr. Roth\(^3\(^2\) explained how the bands should be positioned when S.W.A. brackets are used. Dr. Andrews finally introduced, for the orientation of the brackets, either with banding, or bonding, the use of the clinical crown long axis (LACC) and the clinical crown midpoint (LA) mentioned earlier. This controversy and the various ideas and methods of bracket positioning which have been advocated and used by the orthodontists, bring up a matter which might be the reason for the lack of one method of bracket positioning being universally accepted. 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 measureable at all.

For the orthodontists, the anatomy of the teeth is as important as for all the dental specialties or the general practitioner. From the orthodontic standpoint and as it relates to the placement of the appliances, the buccal or labial surface of the teeth, viewed both labially or buccally and mesially or distally, deserves special attention. Wheeler, in his textbook of dental anatomy and physiology, describes the curvatures above the cementoenamel 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. As he mentioned, although variations are always possible, "one may strike an average for that feature" to be used as "norm" in diagnosis for restorative work. He also pointed out that according to his observations, the variation from the average curvature will be uniform for any individual's teeth. As an example, Wheeler compares on graph paper the curvatures of a central maxillary incisor to a maxillary canine, which seem to be the same. However, from the orthodontic standpoint what affects the design of orthodontic appliances 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. From that standpoint, one can observe that even the textbook typical specimens of the same tooth type present an obvious variation which may be extreme among specimens showing uncommon variation\textsuperscript{43}.

Bertram S. Kraus\textsuperscript{23}, et.al. in a study of the masticatory system, mentioned that the maxillary central incisor may show a wide range of variability, particularly with regard to the labial outline, labial lobes, grooves, labial profile curvature, the mamelon the angulation and the size of the roots. The maxillary lateral incisors show a wide range of morphological variation with respect to labial outline, angulation, mesial and distal surfaces and root curvature. For the mandibular incisors, the authors 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.

Finally, R.M.S. Taylor\textsuperscript{29}, who specifically studied the variation in morphology of the teeth, pointed out great variations in tooth morphology, as far as the curvatures, or
bends in axes of crown and root, the labial outlines and dimensions are concerned. This variation, sometimes, is dramatically exaggerated by the abnormal function that the teeth may experience.
FIGURE 1

EXPANSION ARCH (Stoner, Lindquist\textsuperscript{35})
FIGURE 2

PIN AND TUBE APPLIANCE (Stoner, Lindquist35)
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 13 mm. away from the bracket center. (Meyer and Nelson27)
THE LA POINT AND THE LONG AXIS OF THE CLINICAL CROWN (LACC)

Average 5 degrees tip and 7 degrees torque for a left central incisor (Andrews\textsuperscript{3}).
PLACEMENT OF S.W.A. BRACKET ON A CENTRAL INCISOR WITH A PROPERLY POSITIONED BAND.

The frontal view shows the tip of the bracket, crown and the orientation of the bracket to the long axis. The lateral view shows the torque ("A" Co.).
A: The angulated bracket deflects the arch wire which produces a force couple $F_1$, $F_2$. That results in a tipping moment.

B: The torqued slot creates a force couple which produces a moment of torque. (Meyer and Nelson)
CHAPTER III

MATERIALS

The adjustable orthodontic bracket is a device which provides the possibility to orient and secure an orthodontic slot at different locations on the buccal and labial surfaces of the teeth. This is an assembly which includes the base, the holder, the orthodontic inserts and the clamping device.

THE BASE

The base of the adjustable bracket, viewed from the top (Figure 7), is generally square in shape with rounded corners. It is a separable part of the assembly and it presents four sides, the occlusal, gingival, mesial and distal and two surfaces, the back and the front (Figure 7,8). The four sides are the occlusal, gingival, mesial and distal (Figure 8), which are mostly flat. Projected on the occlusal or gingival aspect, there can be seen the central groove of the base and the base wings (Figure 8A). On the mesial and distal aspect of the base, (Figure 8B) the base wings can be seen sideways. The back surface (lingual side) is shaped to a curvature which on the average fits the
labial or buccal surfaces of the teeth. It is curved both mesiodistally (Figures 8A) and occlusogingivally (Figure 8B). With that side, the base contacts the tooth either directly bonded on it, or through the tooth bands. The front side (Buccal or labial) may be slightly spherical or flat (Figure 8A-B). It is narrower occlusally than gingivally for the purpose of minimizing the size of it occlusally. (Figure 7). The surface of this side is properly formed to receive the holder and allow it to rotate and move occlusogingivally. It includes a central groove running vertically and midway from the mesial to the distal (Figure 7). Its shape, as seen from the occlusal or gingival aspect, is dove-tailed in two steps (Figure 8A). That groove is the provided way for a sliding device, similarly shaped. The two small wings extending occlusogingivally on the front surface (labial or buccal) are located one at the mesial and one at the distal side of the same surface. They are curved inside (Figure 8A) for the purpose of containing the holder. Specifically, the holder can slide or rotate within the wings and still remain firmly attached to the base. The desired range of vertical movement of the holder, determines the minimum occlusogingival extension of these wings.

Figure 7: In this drawing, the labial or buccal side of the base is shown in two dimensions. This drawing also shows the arrangement of the central groove and the
side wings.

Figure 8A: This view of the gingival or occlusal sides shows the dove-tail shape of the central groove and the design of the base wings. The groove is dove-tailed in two steps to avoid the weakening of the base. The wings are shaped in such a manner as to contain beneath them the holder.

Figure 8B: This shows the mesial or distal side. From this aspect, we can see the base wing.

THE HOLDER

This part of the assembly is a piece separable from the base. For describing purposes, it can be visualized as consisted of two parts: the holder base (Figure 9b) and the body (Figure 9a). It resembles the conventional edgewise bracket in the shape of the bracket wings, used to pass the ligature ties underneath them to secure the arch wires (Figure 10). The holder base is generally round and its mesial and distal edges are beveled or rounded in such a manner as to correspond to the shape of the inside of the base wings (Figure 24). It interfits beneath them, so that the entire holder remains firmly attached to the base. Simultaneously, there is enough clearance between the holder base and the base wings, as to allow the operator, when the clamping device is not tied, to rotate or move the holder to a new position, by exerting slight pressure on it. The occlusal and gingival sides of the holder base (Figure 11)
do not function with the base wings but they serve the purpose of providing enough material for strength. Their proper shape is such as not to interfere or extend beyond the base when the holder assumes the most occlusal or the most rotated positions. For this reason, the occlusal end of the holder base is flattened and beveled (Figure 11,f,10), instead of being round. The gingival end is enlarged properly to provide space for the central opening containing the screw (Figure 11-b,d).

The body of the holder (Figure 9A,10) is similar to the conventional edgewise brackets, preferably the "twin" or "siamese" type. It has four wings, two occlusally and two gingivally, for tying the ligatures. The holder, instead of carrying the orthodontic slot mesiodistally across it, provides a recessed way extending mesiodistally where removably an insert fits, carrying the orthodontic slot. This insert rests over an opening which extends to the base (Figure 10). That opening is occupied by the screw when the bracket is fully assembled. The perforation must be large enough to accommodate insertion or removal of the screw, which rests on a provided appropriate shelf within the opening in the holder base (Figure 10). The opening is extended or enlarged suitably, mesially and distally to provide room for the screw, when the holder rotates. The magnitude of enlargement is dictated by the desired extend of the rotational movement.
The groove provided for the orthodontic insert, is centrally located occlusogingivally and it has both ends open. In cross section (Figure 10d), it presents six sides (one is open) and serves to support non-rotatably the insert. That is of similar shape and can be inserted into the holder either mesially or distally.

Figure 9: This is an occlusal or gingival view of the holder. It shows how the mesial and distal ends of the holder base are shaped to interfit with the complementing sides of the base wings.

Figure 10: This drawing represents the mesial or distal side of the holder. The two pairs of wings (occlusal and gingival) are not identical in size and shape. The occlusal wings are bent further lingually, to avoid interfering with the opposing teeth. The dotted line in the holder base is a cross section of the central perforation. The hexagonal central groove and insert can also be seen. The dotted slot of the insert is angulated to the standard one 50 degrees occlusally.

Figure 11: In this drawing, the bracket holder is shown from the buccal or labial aspect. The orthodontic insert is in place and there is a rectangular arch wire in the slot. The dotted lines represent the holder base. The outer dotted line is showing the periphery of it and the inners represent the opening in the base and the screw. This opening is not a perfect circle but the mesial and
distal sides are enlarged, to allow for the rotational movement of the holder.

**ORTHODONTIC SLOT OR INSERT**

As it has been already mentioned, the insert carrying the orthodontic slot is shaped so that it fits in the central groove of the holder. When it is in place, it can not rotate. It is inserted into the holder either mesially or distally and it stays in place itself if it is properly sized as to be tied in the groove due to friction. The precise fit of the insert in the groove is a prerequisite in order to avoid any play of the insert in the groove or loosening of it when there is no wire tied in the slot. The irregular hexagonal shape is the preferred one because it permits non-rotatable close relation of the insert to the holder and also provides enough room for the slot to be angulated (torqued).

The range of angulation of the slot within the insert for torque requirements, is restricted by the size of the insert which cannot exceed certain limits. However, this hexagonal insert can accommodate as much as 50 degrees of rotation (torque) of a slot .018 x .025 inch or .022 x .028 inch (Figure 6). Positive or negative torque of a certain amount can be accomplished by one insert only, since it can be inserted in two different ways giving the same but opposite torque.

**Figure 12:** That is a drawing showing an insert from
the mesial or distal aspect. Its periphery is consisted of six sides of which one is the open wall of the slot. In the case of a 0 degree rotated slot (torque), two pairs of sides are equal and symmetrical (a with b and c with d).

Figure 13: This drawing represents an occlusal or gingival aspect of an insert. The two sides on this view are unequal (a and c, or b and d).

Figure 14: It shows the buccal or labial aspect of an insert. The occlusal and gingival sides in this view are equal (a,b). On each side of the slot (occlusal and gingival), there are two surfaces (1,2) inclined towards the slot. They are to facilitate the insertion of the arch wire into the slot.

Figure 15: This drawing shows a cross section of an insert with anti-rotation. One end of the slot is raised compared to the others.

CLAMPING DEVICE

This is the device which releaseably interlocks the holder with the bracket base. As mentioned before, the holder remains attached to the base due to the existing interfit between the base wings and the mesial and distal sides of the holder base. However, in order to ensure a rigid fixation of the holder to the base and therefore, of the orthodontic slot to the tooth, the clamping device is needed. It permits vertical and rotational movements of the holder and it also firmly retains the holder at a
certain location. That is accomplished by using a sliding device which interfits within the central groove of the base. Two of the opposing sides of the slide are dovetailed, complementing the inner sides of the base groove. The other two sides of the slide, the lingual and labial or buccal are shaped in such a manner that the lingual follows the bottom of the central groove and the labial or buccal constitutes a continuation of the buccal or labial (front) surface of the base (Figure 24). Approximately at the middle of the slide there is a threaded hole as large as the dimension of the slide permits without endangering the strength of it. In this hole, a screw fits which can be tied when the locking of the holder is desired. This sliding device does not extend further than the occlusal or gingival end of the base, when the holder assumes the most occlusal or gingival position respectively.

The screw element of the assembly is consisted of the central stem which carries the threads and fits in the threaded hole of the slide. The height of it does not exceed the thickness of the slide. Inside the screw, there is a depression, suitably shaped to admit an allen wrench or some other tightening device. The round top of the screw (Figure 16A) is properly sized so it can fit into the opening of the holder base and rest on the provided shelf in the lower part of the opening (Figure 11e). The thickness of it is such, that it does not interfere with the insertion of
the orthodontic insert.

Figure 16A: This drawing is a top view of the screw element. In this, the shape and the relative size of the key opening is seen.

Figure 16B: In this drawing, a cross section of the clamping device is shown. The opening inside the screw is the provided space for fitting a suitable key to release or tighten the device.

DIMENSIONS

From the figures No. 22, 23 and 24, which show scaled three different aspects of the entire assembly, one can estimate the dimensions of the bracket. Assuming that the orthodontic slot in those drawing is .018 x .025 inch or .46 x .635 mm., each square of the graph is subsequently .25 mm. x .25 mm. in dimension, because the slot in the drawings covers approximately an area of 1.8 by 2.5 squares. Therefore, it is possible to calculate the real dimensions of those specific embodiments in total and of each one element separately, by comparison with the slot.

THE HOLDER

Occlusogingivally, from wing tip to wing tip (Figure 23) it is 14 squares x .25 = 3.5 mm.

Buccolingually (Figure 23) it is 8 sq. x .25 = 2 mm.

Mesiodistally (Figure 24) it is 14 sq. x .25 = 3.5 mm.

THE BASE

Occlusogingivally (Figure 22) the base is 16 sq. x .25 = 4 mm.
Buccolingually; from the bottom of the base to the top of the base wing (Figure 23) it is 8 sq. x .25 = 2 mm.

Mesiodistally (Figure 22.24) it is 16 sq. x .25 = 4 mm.

**BASE WINGS**

Occlusogingivally the base wings extend 10 sq. x .25 = 2.5 mm. Their width mesiodistally is 2 sq. x .25 = .50 mm. and buccolingually their height is 2 sq. x .25 = .50 mm.

**THE ORTHODONTIC INSERT OF THE BRACKET**

Occlusogingivally (Figure 22,23) it is 5.8 sq. x .25 = 1.45 mm.

Buccolingually (Figure 23) it is 5 sq. x .25 = 1.25 mm.

Mesiodistally (Figure 22) it is 14 sq. x .25 = 3.5 mm.

**THE SLIDE (clamping device)**

Buccolingually (Figure 24) it is 4 sq. x .25 = 1 mm.

Mesiodistally (Figure 24) it is 10 sq. x .25 = 2.5 mm.

**THE SCREW**

The buccolingual height is 6 x .25 = 1.5 mm.

The diameter of the stem is 4 x .25 = 1 mm. and the diameter of the top of the screw is 8 sq. x .25 = 2 mm.

The total buccolingual height of the entire bracket (Figure 23) is 14 sq. x .25 = 3.5 mm.

The largest dimension occlusogingivally and mesiodistally of the bracket coincide with the respective dimensions of the base.

In the case that the orthodontic slot is .022 x .023 inch or .56 x .71 mm. a deeper and wider slot is cut into the
insert. Therefore, no dimension change is needed of any other of the bracket elements.
FIGURE 7

TOP VIEW OF THE BASE

a, b: base wings

 c: central groove
FIGURE 8 A-B

A: OCCLUSAL OR GINGIVAL VIEW
a, b: base wings
  c: central groove

B: MESIAL OR DISTAL ASPECT
b: base wing
OCCLUSAL OR GINGIVAL ASPECT OF THE HOLDER

a: body of the holder
b: holder base
FIGURE 10

MESIAL OR DISTAL ASPECT OF THE HOLDER

a: gingival bracket wing
b: holder base
c: orthodontic slot
d: orthodontic insert
e: the perforation projected on that side
f: the shelf
FIGURE 11

LABIAL OR BUCCAL VIEW OF THE HOLDER

a: the bracket wings
b: the enlarged area of the holder base
c: orthodontic insert
d: central opening
e: the screw
f: holder base (flattened and beveled area)
g: arch wire
h: center of the screw and perforation
i: center of the holder base
MESIAL OR DISTAL VIEW OF AN INSERT

Solid line: slot with no angulation
Dotted line: slot angulated 50 degrees
FIGURE 13

OCCLUSAL OR GINGIVAL VIEW OF AN INSERT
FIGURE 14

BUCCAL OR LABIAL VIEW OF AN INSERT

f: orthodontic slot (0 degree torque)
FIGURE 15

GROSS SECTION OF AN INSERT

a: bottom of the orthodontic slot
FIGURE 16
THE CLAMPING DEVICE

A: TOP VIEW OF THE SCREW ELEMENT
B: SECTION OF THE SLIDING DEVICE AND SCREW
a: the screw
b: slide
A: BUCCAL OR LABIAL ASPECT
B: MESIAL OR DISTAL ASPECT
C: OCCLUSAL OR GINGIVAL ASPECT
FIGURE 18

THE BRACKET HOLDER

A: MESIAL OR DISTAL ASPECT
B: OCCLUSAL OR GINGIVAL ASPECT
C: BUCCAL OR LABIAL ASPECT
FIGURE 19

A: MESIAL OR DISTAL ASPECT
B: OCCLUSAL OR GINGIVAL ASPECT
C: LABIAL OR BUCCAL ASPECT
THE BRACKET ASSEMBLED

A: BUCCAL OR LABIAL ASPECT
B: CROSS SECTION OF THE BRACKET FROM THE OCCLUSAL OR CINGIVAL ASPECT
C: MESIAL OR DISTAL ASPECT
FIGURE 21

THE ORTHODONTIC INSERT

A: Buccal or labial aspect
B: Mesial or distal aspect
C: Occlusal or gingival aspect
FIGURE 22

TOP VIEW OF THE BRACKET ON GRAPH PAPER
FIGURE 23

THE MESIAL OR DISTAL VIEW OF THE BRACKET ON GRAPH PAPER
A MESIODISTAL CROSS SECTION OF THE BRACKET ON GRAPH PAPER (OCCLUSAL OR GINGIVAL VIEW).
PICTURE 1

THE BUCCAL OR LABIAL VIEW OF A BRACKET MODEL
THE GINGIVAL VIEW OF A BRACKET MODEL
THE MESIAL OR DISTAL VIEW OF A BRACKET MODEL
THE BUCCAL OR LABIAL VIEW OF THE BRACKET HOLDER BEING ANGULATED ON THE BASE (WITHOUT THE INSERT).
CHAPTER IV

RESULTS

An appliance, associated with the adjustable brackets will function quite differently than the conventional mechanisms. The difference relates to the manner in which the appliances are activated. Conventionally, it is carried out by bending the arch wires, or by providing preadjusted brackets. The adjustable brackets without eliminating these options, make it possible to produce various force vectors of any direction and amount, by only adjusting the brackets during the treatment. The adjustability can be explained in three different types of adjustments: the vertical, the rotational (tip or second order) and torque (third order) adjustments. These constitute the basic function of the adjustable bracket.

ASSEMBLAGE OF THE BRACKET

The bracket described in the previous chapter is consisted of the base, clamping device, the holder and a set of orthodontic inserts carrying the orthodontic slot. These elements can be assembled in three steps. First the screw
is inserted in its place in the holder and then the slide of the clamping device is loosely attached to the screw. Second, the slide is inserted into the central groove of the bracket base, which may be attached to the tooth, and the holder is slid beneath the base wings. The screw is then tied to secure the holder at the desired location. Third, the proper insert is placed into the holder. Starting from that position, right at the beginning or at any other subsequent stage during the treatment, the various adjustments of the brackets can take place.

**VERTICAL ADJUSTMENT**

The holder can be moved occlusogingivally along the bracket base when the screw of the clamping device is not tied. That permits the bracket slot to be placed vertically at different locations on the labial or buccal surfaces of the teeth. During the vertical adjustment, the holder remains attached to the bracket base as long as the mesial and distal edges of the holder base are confined beneath the base wings. When the holder moves vertically, the slide of the clamping device is also moving in the central groove of the base which is the way provided for the slide. The holder at any location within its track can be stabilized by tightening the clamping device. When the screw is tightened, the slide is wedged against the dove-tail sides of the central groove. Simultaneously, the screw secures the holder by pressing the shelf,
which is inside the central opening of the holder against the bracket base (Figure 5).

The range of vertical movement is approximately 1.5-2 mm. It is limited by the extent of the base wings which is 2.5 mm. occlusogingivally. It is not possible to utilize the entire length of them because it seems probable that the stability of the holder at the extreme occlusal or gingival positions might not be adequate. This is the reason that an extent of 1.5 to 2 mm. instead of 2.5 mm. total vertical adjustment is thought to be practically obtainable.

**TIP OR SECOND ORDER ADJUSTMENT**

The term second order movement has been mainly used to indicate mesial or distal changes of the axial inclination of the teeth. Among the brackets in the market, carrying preangled slots, there is one, the "maximum extraction bracket" ("A" Co.), for canines which has built-in tip of 15 degrees. This is probably the most of angulation that could be required in any case. Otherwise, it varies at much lower level and it is different from tooth to tooth. The adjustable bracket illustrated previously, permits to rotate the holder 22.5 degrees mesially or distally. This results in an angulation of the orthodontic slot of the same amount.

When the clamping device is released, the holder rotates about an axis approximately located at the center of the holder base (Figure 5). The opening which accommodates the seating of the screw, is made on the holder base off this
center and therefore, during the rotation of the holder it will move on an arc around the center of the holder (Figure 5). For this reason, the opening must be enlarged at its mesial and distal ends, altered in this way, from a round opening to a peculiar oval one; because, when the holder is rotating about its central axis, the opening which is off center moves against the stable screw. Therefore, the rotational movement of the holder can be made possible only if the opening is suitably enlarged in the aforementioned manner. The extent of this enlargement will determine the extent of rotational movement.

If the screw and the opening were centered in the holder base, then the range of the rotational movement would be much wider. In that case, it would be restricted only by the shape of the periphery of the holder base which interfits with the base wings. However, it was felt that such an arrangement does not provide any mechanical advantage. Because the screw, bearing a central position, might get released when a counterclockwise moment was applied on the bracket by the wire. That moment would obviously tend to release the screw.

In conclusion therefore, the orthodontic slot carried by the holder, can be adjusted at different degrees of angulation ranging from +22.5 to -22.5 degrees.

**THIRD ORDER ADJUSTMENT - TORQUE**

The torquing movements relate to the buccolingual or
labiolingual axial inclination of the teeth. They have always been among the most critical movements to accomplish and a very important factor to the outcome and stability of the orthodontic treatment. Conventionally the torquing movements have been made possible either by twisting the rectangular arch wires properly (third order bends) or by providing brackets with pretorqued slots.

The adjustable bracket for torquing purposes is provided with a set of orthodontic inserts, otherwise identical except for the rotation of the slot along its axis. That means that when more torque for a tooth is needed for a certain arch wire, the orthodontic insert has to be replaced by another one, selected of a set of orthodontic inserts, with different slot rotation (torque). A similar result can also be achieved by altering the arch wire size when the insert remains the same. Therefore, with the adjustable bracket due to the possible combination of wire sizes and orthodontic slots differently torqued, the torque requirements can be met with a variety of small increments.

The range of torque possible with the certain inserts described, extends from $+50$ degrees at the most, to $-50$ degrees when the same insert is reversed (Figure 12). The increments in degrees of torque between any two consecutive inserts may be varied as it is necessary.
CHAPTER V

DISCUSSION

The clinical application of the adjustable bracket presents certain advantages over the standard and the preadjusted brackets. These advantages relate to the possibility of adjusting this bracket during the initial placement on the teeth, throughout the active treatment and during the finishing stages.

The placement of the adjustable bracket on the teeth, like the conventional bracketing, must result in having the brackets oriented accurately at desired locations on the teeth without interfering with the occlusion. Any errors which might occur during this procedure, in contrast to the conventional method, do not necessitate replacement of the brackets or bending the arch wire. They will be corrected by properly adjusting the bracket. Vertical adjustments will compensate for the errors in placing the base of the bracket either gingivally or occlusally to the right position. Angular adjustment (rotation of the holder) will correct the errors which result in having the bracket slots angulated mesiodistally more or less than is necessary.
Finally the mesiodistal misplacement of the brackets which causes undesirable rotation of the teeth, is compensated by using the appropriate "anti-rotating" inserts. They have one end of the slot raised buccolingually or labiolingually compared to the other (Figure 15).

When the placement and assemblage of the brackets are completed on all the teeth, the bracket slots must be arranged with a certain degree of mesiodistal tip, torque and vertical position. Depending on the treatment plan and mechanics, the initial slot placement on certain teeth may be such as to accomplish the final positioning. However, on other teeth, which are severely malposed, it will be such as to accomplish only an increment of the total movement which is necessary for the final tooth positioning. That will permit the operator to use, from the beginning, unbent round or even rectangular arch wires of a size close to the slot dimensions. Because the incremental adjustment of the brackets will make it possible to engage these wires into the slots without distorting them or exerting too heavy forces on the teeth. The light round wires, which are conventionally used for leveling, usually have incorporated first and probably second order bends. When these wires are deflected into the slots for the leveling of the teeth, they tend to twist within the slots. That happens because the round wires do not bind in the rectangular slots and the resistance to torsion in that case is much lower than the
resistance to deflection. That relates to the length of the wire which is deflected, compared to the length of the wire which is twisted. In the first case, it is equal to the interbracket distance of the adjacent teeth and in the second, it extends from the molar to the midline. Therefore, it is easier for a round arch wire to rotate in the slots rather than to be deflected. That may result in altering the effective direction of the bends by converting the second order bends to unwanted first order steps of the wire or vice versa. With the proposed bracket in the subsequent stages of the treatment, the adjustments of the brackets will include the necessary corrections of the initial settings and adding of new increments of adjustments. If at the end, most of the teeth are short from their final position, the last increment for the tooth movements can be added by either adjusting all the brackets again, or by replacing the arch wire in use with a heavier one.

With the preadjusted appliances, which have the total amount of adjustments prefixed into the brackets, the only way to correct the tip, torque and vertical position of the slot is to bend the arch wire. In subsequent stages, the heavier wires which are needed in order to progressively fully express the adjustments, built into the bracket must also carry these compensating bends. That introduces an additional variable to the appliance manipulation which relates to the difficulty of repeating certain bends from
wire to wire.

Specifically, in extraction cases or malocclusions with extensive spacing, the slots of the brackets must have the proper mesiodistal angulation to keep the teeth upright during retraction and the proper torque to keep the tooth roots away from the cortical plates of bone. When the adjustable bracket is used, the bracket slot is set with a certain degree of mesiodistal tip and torque which the operator estimates as adequate. That depends on the size of the arch wire and the force which will be applied. If during the retraction, the tooth tends to tip or deviate from the expected movement, the bracket on that tooth will be accordingly adjusted. When the preadjusted brackets are used and the teeth are being retracted on a certain arch wire with a certain force, any deviation from the expected movement is normally corrected by incorporating second and third order bends into the wire. Although these bends may correct the tooth position, they may interfere with the sliding of the brackets on the arch wire.

During the sliding movements of the teeth there is friction between the arch wire and the brackets. With the adjustable bracket, the friction can be reduced by using during the retraction inserts with wider slots on the teeth which are being retracted than the rest of the teeth. That, creates more freedom of movement between wire and bracket slot and permits heavy wires to be used during retraction.
The stiffness of the wire is proportional to the fourth power of diameter and therefore the heavy wires provide better control in keeping the teeth upright during retraction than the light wires. With preadjusted or standard brackets (especially .018 x .025) usually light round wires are used during retraction. These create less friction than the heavier round or rectangular wires but they have some disadvantages. First, they do not provide any control on the buccolinguall root position during retraction and second, they are weak in keeping the teeth upright.

Towards the end of 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 the roots of the teeth. When factors such as variations in tooth morphology, tooth irregularities and errors in appliance manipulation are involved, it is difficult to achieve accurately these goals with the conventional fixed appliances. The only way to accomplish that, is to incorporate into the final arch wires, very meticulous bends. With the adjustable bracket, this can be achieved simply by adjusting it in small increments until the teeth occupy their best positions.

In special situations like Bolton discrepancies, (tooth mass excess in one jaw compared to the other) severe
Class II's, crossbites and unusual extractions, the finishing of the active treatment becomes even more difficult and requires special adjustments of any appliance to accomodate to more difficult mechanics or unique individual tooth positioning. When the adjustable bracket is used, there is no need for wire bending in these situations. The bracket is properly adjusted in order to bring the teeth where they provide optimum occlusion. Specifically in Bolton discrepancies and severe skeletal Class II's (large facial convexity) which will be treated orthodontically, the axial inclination and vertical position of the anterior teeth must be individualized, depending on the degree of discrepancy. The purpose of that is to establish proper overjet and overbite in these cases, after the buccal segments occlude as expected. This is accomplished by adjusting the bracket to torque, tip, extrude or intrude the anterior teeth. In crossbites, mainly dental anterior or posterior, the torque of the teeth which have been moved out of crossbite may be specifically applied by using the right inserts in the bracket. The amount of torque some times may need to accomplish some degree of overcorrection. Finally, in unusual extraction cases, where the removed teeth (second bicuspids, incisors, molars) are not the first bicuspids, the adjustable bracket makes it possible to control the space closure efficiently. Also, the necessary compensations in the position of the
molar teeth (torque, tip and rotation) after extracting teeth only on one dental arch can be accomplished by adjusting the bracket properly. The extraction series preadjusted brackets are usually available only for the first bicuspid extractions.

An additional advantage of the adjustable bracket relates to the possibility that this device provides for reuse of all the elements of it, except for the base. At the end of treatment, when the brackets have to be removed, the clamping device is released and then the holder with the clamping device is slid out of the base and becomes available to be reused. The base, on the contrary, which is fixed on the tooth, like the conventional brackets, can not be reused as it will be distorted upon removal from the tooth.

As mentioned in Chapter III, Materials, the lingual surface of the base (the side which attaches to the tooth) is curved vertically (occlusogingivally) and horizontally (mesiodistally) so it fits on average, the labial and buccal surface of the teeth. Because there are similarities in the degree of curvature mesiodistally and occlusogingivally between canines and premolars, it might be possible to construct one base which on average, fits these teeth. Also, it might be possible to have another base for all the incisors because they are flatter mesiodistally than the canines and premolars. The error which is introduced
because of the lack of absolute fit between base and tooth surface (which practically can not be achieved) can be compensated for, like the errors in bracket placement.

In the case that wide, medium and narrow brackets are necessary for tipping and rotating control (like the conventional brackets), this can be satisfied by making only the holder and the inserts of different widths, not the bases. They can be used interchangeably at different stages of treatment. For example, the leveling may be more efficient by using narrow brackets which allow more interbracket distance. Later, in order to better control the tooth tipping and rotation, wider brackets may be used.

In this discussion, some comparisons were made between a theoretical model of the adjustable bracket with the existing standard and preadjusted brackets. The conclusions which were derived out of these comparisons mainly relate to the idea of having an appliance with adjustable brackets rather than to the specific bracket itself. That was designed in a way that it serves this idea efficiently without jeopardizing any of the clinical advantages of the standard or preadjusted appliances. The value of this basic design will be justified only when the bracket is used clinically. At that time, also some modifications might be introduced to the basic design which was presented in this project.
CHAPTER VI

SUMMARY AND CONCLUSIONS

In this study the design of an adjustable bracket was presented, analysed and discussed. First, the various parts of the bracket, the base, the holder, the clamping device and the orthodontic inserts were described from the standpoint of their shape, variations and dimensions. In scaled drawings, it was shown how the bracket elements fit together and relate to each other. From the figures 22, 23, and 24 where the drawings of the assembled bracket were shown on graph paper, the real dimensions of the bracket were estimated by comparing the size of the various elements to the bracket slot. It was also explained how the specific form of the various elements of the bracket allows for the expected range of adjustability and stabilization of the bracket slot in various positions.

This bracket clinically can be used with unbent arch wires to control the tooth movements in all the possible treatment procedures. In comparison with standard or preadjusted brackets it provides easier bracket placement and more efficient control of tooth movements during the
orthodontic treatment.

In conclusion, this bracket functions like a preadjusted bracket, which is capable of being readjusted any time during the treatment. The readjustments can accomplish changes in the vertical position, angulation, torque and rotation of the slot. That feature makes it possible to compensate for variations in tooth morphology from patient to patient and meet the treatment requirements for all malocclusions.
REFERENCES


32. Roth, R.: The Straight Wire II Mechanics Course; The Foundation for Advanced Continuing Education.


34. Steiner, C.C.: "B Tere One Best Orthodontic Appliance"; Angle Orthodontist, 3:277, 1933.


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