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**A Cephalometric Comparison of Class II Extraction Cases Treated
with Tip-Edge and Edgewise Techniques**

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**A CEPHALOMETRIC COMPARISON OF CLASS II EXTRACTION
CASES TREATED WITH TIP-EDGE AND EDGEWISE TECHNIQUES**

BY

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Thesis submitted in partial fulfillment of the requirements for the degree of
Magister Chirurgiae Dentium in Orthodontics in the Faculty of Dentistry,
University of the Western Cape.



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DECLARATION

I, declare that “ **A CEPHALOMETRIC COMPARISON OF CLASS II EXTRACTION CASES TREATED WITH TIP-EDGE AND EDGEWISE TECHNIQUES**” is my own work and that all the sources I have quoted have been indicated and acknowledged by means of references.



ACKNOWLEDGEMENTS

I wish to acknowledge my sincere gratitude to the following people for the assistance given to me in this research project (Listed in no specific order of preference):

1. Prof Harris and Dr Els for their immeasurable support throughout the writing of this mini thesis.
2. Prof Shaikh for assisting with the Dolphin Program.
3. Prof Myburgh for the support and encouragement he showed towards my project and the programme as a whole.
4. Prof Madsen for the fantastic analysis and information that he provided.
5. Dr Kombrink and his staff for providing me with the records and all the information I needed.
6. Dr Barrie for being readily available to assist at all times.
7. Drs Nkosi and Murphy for the great contribution they gave me towards choosing the topic for my project.
8. Dr Hudson for having organized the patient records so well.
9. Dr Johannes for donating the Dolphin Program to the Department.
10. Drs Ginsberg for his willingness to avail the records.
11. Miss K Crombie and the staff from the radiology department, who were always available when needed.
12. Miss R November for her support and willingness to assist.
13. A special vote of thanks to all the consultants in the orthodontic department for the constructive criticism towards the research proposal and all the support they gave.

14. To all not mentioned by name who assisted with any part of the thesis.

15. Dr M.V. Buthelezi for the constant support he has given me throughout my academic program as a registrar.



DEDICATION

This thesis is dedicated to my family, friends and colleagues for all the support and encouragements they gave in making my education possible.



KEYWORDS

Cephalometric Analysis

Cephalometric Radiography

Tip-Edge Technique

“Self-Limiting” Feature

Differential Tooth Movement

Australian Stainless Steel Wire

Edgewise Technique

Class II Malocclusion

Premolar Extraction

Class II Elastics



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ABSTRACT

The Tip-Edge and edgewise techniques are the main techniques that are mostly used in orthodontics, and are applicable to the treatment of any type of malocclusion from the most simple to the most complex. The edgewise bracket wire combination produces bodily tooth movement simultaneously or separately in all three planes of space and hence permits correction of the most extreme tooth malpositions. On the other hand Tip-Edge offers a differential tooth movement (just like the previously used Begg technique) within an edgewise based bracket system (Parkhouse 2003).

When treating patients using the Tip-Edge technique, it is recommended that a specialized archwire i.e. Australian stainless steel wire be used. This wire can be described as a round austenitic stainless steel wire that is heat-treated and cold-drawn to its proper diameter. This was done in order to produce its special and needed properties such as toughness, resiliency and tensile strength (Kesling, 1985). It is used in conjunction with light (2oz) class II elastics.

The aim of this study was to compare cephalometric changes in skeletal and dento-alveolar parameters in cases treated by these two different orthodontic techniques. This was to be established by calculating and comparing the pre- and post-treatment cephalometric variables of cases treated with these techniques by looking at the skeletal and dento-alveolar measurements.

Thirty Tip-Edge and thirty edgewise treated cases that had class II malocclusion, had extraction of four premolars and were treated with Class II elastics were selected. The gender distribution between the Tip-Edge and the edgewise techniques were 47% and 60% respectively for females. For males it was 53% in Tip-Edge and 40% in the edgewise techniques.


The mean ages were 17.8 for Tip-Edge and 13.8 for edgewise techniques. The pre- and post-cephalometric radiographs were collected and the landmarks used were digitized using a Dolphin 10.5 Imaging and management solutions program.

The results indicated that Tip-Edge technique showed responses that were more variable than in the edgewise technique. The distances moved by all four teeth (upper first molar, lower first molar, upper central incisor and lower central incisor) were more in the Tip-Edge technique compared to the edgewise technique. However, the differences in overbite, overjet and ANB were not that significantly different between the two techniques. These results indicate that there were significant differences between the pre- and post-treatment cephalometric variables in cases treated with Tip-Edge and edgewise techniques.

When the data was pooled, the correlation of the outcomes with age, gender and treatment time showed no significant differences between the two techniques, for example, the Chi-Square for gender was 0.3006. The Spearman Correlation Coefficients of the age factor were only significant for two variables, namely: Total distance moved by the lower first molar (t2) and the Total distance moved by the lower central incisor (t4). Their values were 0.0445 and 0.0023 respectively for technique 1 (Tip-Edge) and 0.0060 and 0.0132 respectively for technique 2 (edgewise).

In conclusion, it was evident that the Tip-Edge technique showed more variability in tooth movement as compared to the edgewise technique, thus there were significant differences in terms of tooth movement between the two techniques. There were no significant differences in overbite, overjet and ANB changes between the two techniques

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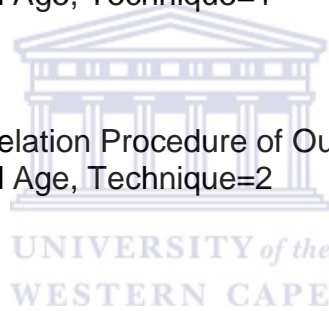
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Radiographic principles were first introduced into orthodontics by van Loon in 1915. In 1922, Pacini recognized that roentgenographic cephalometry was more accurate than anthropometric methods. Radiographic cephalometrics was first introduced by Hofrath in Germany as well as Broadbent in the United States around the early 1930's. He also adapted van Loon and Pacini's principles. According to Proffit (2007), the original purpose of cephalometry at the time was mainly for research on growth patterns in the craniofacial complex. Now, with so much advancement in the development of cephalometry, dentists and orthodontists use radiographic cephalometry as a clinical tool for the study of malocclusion as well as underlying skeletal disproportions.

The edgewise technique was first introduced by Dr E.H. Angle (who is widely recognized as the father of Orthodontics) in 1925. Included in Angle's philosophy is the concept of establishing and maintaining the maximum anchorage potential of each tooth throughout treatment (Angle, 1907).



Begg's Philosophy was first introduced in 1954 by Begg, when he described the "differential force" as the ability to pit bodily moving forces against tipping moving forces. The essence of this technique is the utilization of crown tipping followed by root uprighting in order to achieve bodily movement.

The Tip-Edge bracket system was first introduced by Dr PC Kesling in 1988, when he made an analysis of tooth movements that took place in cases treated by Begg (Kesling, 1988; Kesling, 1989a; Miyajima and Lizuka, 1996; Harrison 1998). In essence, Tip-Edge is a differential tooth movement (which is a Begg technique) within an edgewise based bracket system (Kesling, 1988 and 1989a).

Class II elastics have been used in the correction of Class II malocclusion since the early days of orthodontic treatment (Payne, 1971; Ellen et al., 1998, Reddy et al., 2000; Graber et al., 2005). According to many authors some undesirable effects can occur with these elastics (Langlade, 1978; Ellen et al., 1998; Philippe 1995).

The effects of Class II elastics include mesial movements of the mandibular molars, movements and tipping of the mandibular incisors, distal movements and tipping of the maxillary incisors, extrusion of the mandibular molars and maxillary incisors, and clockwise rotation of the mandibular and the occlusal planes (Ellen et al., 1998). Other studies compared anchorage in bioprogressive versus standard edgewise treatment in Class II correction with intermaxillary elastic force (Hanes RA, 1959; Adams et al., 1972; Gianelly et al., 1984; Remmer et al., 1985; Nelsen et al., 2000).

Class II elastics in the Tip-Edge appliance are worn full time from the beginning of treatment. A force of 50 gram is recommended however if the forces exceed 50 grams; there is a risk of losing lower molar control (Kesling, 2003; Parkhouse, 2003).



2. LITERATURE REVIEW

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2.1 CEPHALOMETRIC RADIOGRAPHY AND ANALYSIS

Cephalometric analysis is a useful diagnostic tool to determine facial type and its growth pattern, so that the clinician can determine facial disharmonies in order to centralize therapeutic measures during treatment and modify facial growth.

In 1915 van Loon was the first to introduce cephalometric principles into orthodontics. In 1922, Pacini recognized that roentgenographic cephalometry was more accurate than anthropometric methods that were in use and predicted that the method would be useful in studying developmental classification and deviations of the human skull.

Pacini identified the following anthropometric landmarks on the roentgenograph: gonion, pogonion, nasion, and anterior nasal spine. He also located the centre of the sella turcica and the external auditory meatus. He measured the gonial angle and the degree of maxillary protrusion. Salzmann points out that Atkinson (1922) advocated the use of cephalometric X-rays in relating the soft-tissues to the face and jaws.

Broadbent (1931) adapted the craniostat, the device used by anthropologists for holding dried skulls for radiography, as well as to hold the head of a living child in a fixed position. By means of this head holder, and a standardized radiographic technique, Broadbent was able to take radiographs in a position that could be reproduced on successive occasions. Radiographic cephalometrics had been conceived. Broadbent's technique proved to be more accurate, and also permitted the gathering of greater amounts of information as regards growth and development.

In 1937, Broadbent remodified the cephalometer to include the taking of frontal film without having to move the patient's head from the

cephalostat. Various points and planes were established on which to superimpose serial tracings of cephalometric radiographs; Broadbent was able to determine changes in the living head, that could be attributed to developmental growth or to orthodontic treatment. At the same time, Broadbent reported on a landmark, found above the face in the cranial base that he felt was a less variable point for cephalometric appraisal than the Frankfort horizontal. He called this point Registration Point or Point R.

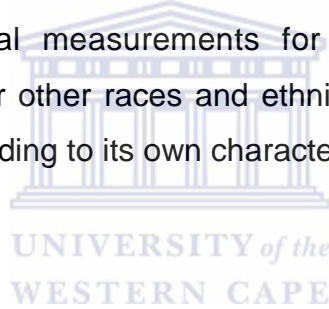
Broadbent's method of studying growth patterns was further explored by Brodie (1941) in a study of growth of the human head from 3 months to 8 years of life and by Broadbent himself (1942) when he studied 3500 children over a 7 year period. Thus, initially, Broadbent's technique of cephalometric radiography gave the clinician a greater knowledge and perspective of growth changes in the human head, with and without orthodontic change. It was not until the work of Wylie (1947) and Downs (1948), however, that a comprehensive effort was made at the application of cephalometrics to orthodontic diagnosis. The measurement of the head from the shadows of bony and soft tissue landmarks on the radiographic image became known as roentgenographic cephalometry (Krogman and Sassouni, 1957).

Jarabak (1972) has defined cephalometrics as the science that segments the dentofacial complex in order to assess the relationship among segments and how individual growth increments or their changes can affect the whole complex.

In its early years, cephalometric analysis was criticized as being just a "numbers game," that led to orthodontic treatment and aimed at producing particular numbers on a cephalometric radiograph (Owen, 1984; Proffit, 2007) that might or might not represent the best treatment result for that patient. Totally accepting the Steiner compromises and

setting treatment goals solely in terms of producing these numbers could certainly be criticized on that basis. Presently, cephalometric analysis is used worldwide by clinicians for studying the underlying basis for a malocclusion, by looking not only at individual measurements compared with a norm but also at the pattern of relationships, including soft tissue relationships (Proffit, 2007).

Cephalometric norms for different ethnic and racial groups have also been established in many studies. Most investigators have concluded that there are significant differences between these groups, and many cephalometric standards have been developed (Hwang et al., 2002; Miyajima et al., 1996; Swlerenga, 1994; Evanko et al., 1997; Cortella et al., 1997; Huertas & Ghafari, 2001; Basciftci et al., 2003). These studies have indicated that normal measurements for one group should not be considered normal for other races and ethnic groups. Each racial group must be treated according to its own characteristics.



2.2 EDGEWISE TECHNIQUE AND ITS HISTORICAL BACKGROUND

The edgewise appliance, as it is used in present-day orthodontic practice, is applicable to the treatment of any type of malocclusion from the most simple to the most complex. The unique capability of the edgewise bracket wire combination to produce bodily tooth movement simultaneously or separately in all three planes of space permits correction of the most extreme tooth malpositions without the necessary addition of specialized intraoral auxiliaries.

The universal applicability of the edgewise appliance has been achieved by a long process of evolution that began in the late 19th century with the innovative efforts of Edward H. Angle and continues to the present day. The original edgewise appliance represented the culmination of Angle's efforts to design a system that would provide intimate control of tooth position in all three dimensions (McNeill 1974).

An obsession for order motivated Edward Hartley Angle to create, in 1888, the Angle System. This system ultimately resulted in the introduction of the edgewise multi-banded appliance 5 years before Angle's death. He believed that an orthodontic appliance must have five properties:

1. Simplicity: it must push, pull, and rotate teeth.
2. Stability: it must be fixed to the teeth.
3. Efficiency: it must be based on Newton's third law and have anchorage.
4. Delicacy: it must be accepted by the tissues, and it must not cause inflammation and soreness.
5. Inconspicuousness: it must be esthetically acceptable.

He designed a standard appliance composed of a specific number of basic components. He had these components mass-produced so that they could be assembled into a simple, stable, efficient, delicate, and inconspicuous treatment device, without difficulty, in less time and with

minimal pain and discomfort to the patient. This universal application enabled practitioners to treat more patients at a higher level of excellence and at less cost than they had done previously. In effect, it was the beginning of a relationship between manufacturers, suppliers, and orthodontists; it was the Angle System (Vaden et al., 2000).

At each phase in appliance evolution, Angle recognized limitations in design and ingeniously devised means to circumvent them thus giving rise to the next developmental step. Angle's next design was the Edgewise bracket. The edgewise appliance was developed by Angle in 1928. To overcome the limitations in the ribbon arch, Angle changed the form of the brackets by locating the slot in the center and placing it in a horizontal plane instead of a vertical plane, hence the term "edgewise."

Angle introduced the edgewise bracket two years before he died. He had very little time to teach its manipulation, develop it further, and improve its use. However, the usage of the modern edgewise appliance is based on an amalgamation of mechanical principles derived from many sources but retaining the central capability of three-dimensional tooth control through the action of a rectangular wire in a rectangular bracket slot.

Reed Holdaway made the first attempt to alter bracket slots in 1958. He angulated the brackets on the band strip to provide Tweed-style tieback bends on the posterior teeth and artistic positioning bends on the anterior teeth with a flat arch wire (Roth 2000).

The second attempt at devising a preadjusted bracket involved the milling of torque into the face of an edgewise bracket by Ivan Lee. Jarabak in 1961 was the first to combine the two features into an appliance system. Artistic tipping of anterior teeth was accomplished by bracket angulations, while torque was accomplished by milling the slot in the face of the bracket. Andrews was the first to develop a fully preadjusted appliance

(Roth 2000).

Between 1965 and 1971, Lawrence F. Andrews conducted a study of 120 non-orthodontic models with good static occlusion that occurs naturally and compared with the best end results achieved by leading American orthodontists. Andrew's research was based on the premise that what nature does in its own best products should be worthy of emulation (thus his Six Keys to Normal Occlusion). Andrews (1972) took the average values derived from his sample as the ideal tooth positions worthy of replication in orthodontic treatment, and set out to deliver the ideal bracket system: The Straight Wire Appliance.

Roth (1987) developed his prescription values from those of Andrews but allowed for over-correction and finishing treated cases without resorting to placing compensating curve of Spee in the arch wires. Most notable is the increased torque in the upper interiors as well as increased tip to the upper canines. Roth (1987) states that his values also reduce the need to deal with the inventory concerns of multiple appliance prescriptions. In his view, Roth (2000) states that there is no such thing as full bracket expression, and therefore overcorrection must be put into the bracket slot than is actually desired in terms of root position.

McLaughlin, Bennett and Trevisi (1997) also developed their appliance prescription values from those of Andrews but increased palatal root torque in the upper incisors, labial root torque in the lower incisors and reduced lingual crown torque in the lower buccal segments. Canine and incisor tip was also reduced, as was the tip to the upper molars. McLaughlin, Bennett and Trevisi (1997) claim their modifications to Andrews' values are required to improve both clinical control and treatment efficiency.

2.3 THE BEGG TECHNIQUE

The Begg technique is also referred to as the light wire technique. Parkhouse (2003) states that the Begg bracket was in fact a modification of Angle's earlier 'ribbon arch' bracket. Its adoption was thus designed to overcome one of the main disadvantages present in all edgewise systems, i.e. since every tooth is subject to mesio-distal bodily movement produced by the moment from the archwire engagement, this then results in an increasing resistance to retraction.

When looking back, it is evident that Begg undoubtedly stimulated conventional edgewise thinking towards lighter forces and shorter treatment times (Parkhouse, 2003). According to Sims (1964) the use of light wires is not a new concept at all since much of the pioneering development regarding light wires was carried out in New York by Dr. E.M. Griffin more than 30 years ago, also in 1931 Dr Johnson introduced the 'twin arch' appliance which utilizes the properties of light resilient round wires.

"Dr. Begg, after more than 20 years of intensive development, has offered an appliance technique which he assesses in the following terms:

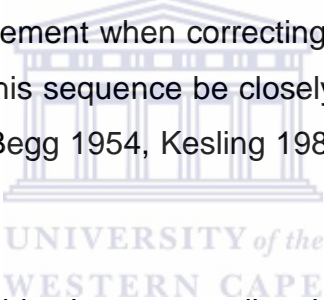
- Correctly applied, the light arch wire technique can produce universal tooth movement with light optimum forces, least discomfort to the patients, minimum loosening of teeth, and least injury to the tooth investing tissues. These same light forces will move the teeth most rapidly and are said to be the most easily controlled forces" (Sims, 1964).

In both this technique as well as the Tip-Edge technique, it is recommended that a specialized archwire be used in conjunction with class II elastics, in order to get best results. This wire is known as the Australian wire and it was developed by A.J. Wilcock. Kesling (1985) describes this wire as a round austenitic stainless steel wire that is heat-

treated and cold-drawn to its proper diameter. This was done in order to produce its special and needed properties such as toughness, resiliency and tensile strength. These features then integrate a balance between hardness and resilience with the unique property of stress relaxation.

TP Special plus wire (yellow-Wilcock) is the mostly recommended one, since it is the most suitable one as it moves the teeth for long distances without the need for it to be reactivated regularly. This is a result of its high resiliency properties. This type of wire is very brittle and when caution is not taken when bending it, it can result in breakage (Begg and Kesling, 1977).

The Begg and Tip-Edge techniques both use a prescribed overall sequence of tooth movement when correcting any type of malocclusion. It is very important that this sequence be closely followed. These take place in three main stages (Begg 1954, Kesling 1988 and Parkhouse 2003) and these are:

- 
- First Stage- Its objectives are to align the anterior teeth in order to eliminate crowding or spacing, correction of deep or open bites and achieve Class I canine and molar relationships.
 - Second Stage- Its objectives are to close remaining posterior spaces, correct or maintain dental midlines, correct posterior crossbites, overrotate severely rotated premolars and also to maintain all corrections achieved during the first stage.
 - Third Stage- Its two main objectives are to maintain all corrections achieved during the first and second stages as well as to achieve final tip and torque inclinations of all teeth.

2.4 TIP-EDGE TECHNIQUE AND ITS HISTORICAL BACKGROUND

According to Barton 1971, Kesling 1992, Parkhouse 1998 and 2003, there are two main ways of attaining tooth movements using fixed appliances in orthodontics, namely: The edgewise technique and the Begg technique.

Several studies have shown that when uprighting or retracting canines, using a straight- wire edgewise bracket system several problems occur. These include: Tipping and extrusion of incisors, deepening of the bite, as well as opening of the bite in the canine-premolar area (Thompson 1988, Kesling 1989, McLaughlin and Bennett, 1998, Burstone, 1977; Rocke, 1994).

The Tip-Edge bracket system was then developed in an attempt to overcome these problems. The Tip-Edge bracket has all the finishing characteristics of a straight wire bracket, that is, in-out compensation, tip, and torque built into the base. The arch wire slot is 0.022 inch. The bracket also contains a vertical slot to accept auxiliaries. The only difference is that diagonally opposed wedges are cut out of the arch wire slot to permit mesial or distal tipping during treatment as shown below (Rocke, 1994; Miyajima and Lizuka, 1996; Parkhouse, 1998).

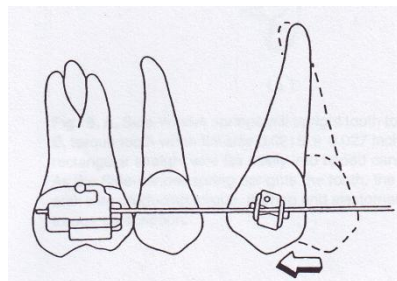


Fig.1 The Tip-Edge bracket slot (Picture taken from Rocke, 1994)

The design of this bracket slot allows for a progressive increase in the wire size, from a 0.022 inch to a 0.028 inch depending on the degree of lateral tipping of a tooth. This is of great advantage in the sense that it does not only eliminate binding between the arch wire and the slot but also allows one to progress directly from 0.016 inch to 0.022 inch round wire or 0.0215 x 0.027 inch rectangular finishing arch wires without binding or patient discomfort (Rocke, 1994; Parkhouse, 1998).

Amongst other factors, one of the most critical adverse effects related to fixed orthodontic therapy is root resorption. The Tip-Edge technique is no exception to inducing root resorption. According to several researchers root resorption has been recognized as a clinical problem in orthodontically treated cases since the 1920s (Ketcham, 1927, 1929; Beck and Harris, 1994). According to DeShields (1969) root resorption occurs in almost every orthodontically treated patient, although Linge and Linge (1983) demonstrated that there is a less chance for root resorption to occur when patients are treated at the age of 11, i.e. before the roots were fully developed, but fixed orthodontic therapy in this age is not really recommended. They explain that perhaps why less root resorption takes place before that age, is due to preventive effect of the thick layer of preentin on young underdeveloped roots.

Several factors contributing to root resorption during fixed orthodontic therapy have been identified by different authors (Kaley and Phillips, 1991; Beck and Harris 1994). These include:

- Length of active treatment (DeShields, 1969; Von der Ahe, 1973; Zachrisson, 1976; McFadden et al., 1989). These authors have shown that the longer the active treatment time, the greater the chances of severe root resorption.

- The force magnitude. Uncontrolled tipping causes root resorption because of high stress levels in the periodontal ligament (Wainwright, 1973; Reitan, 1974). Several researchers found that the contact of maxillary incisors with the palatal cortical plate causes root resorption (Goldson and Henrikson, 1975; Ten Hoeve and Mulie, 1976; Hickman 1986).
- Abnormal, chronic forces such as nail-biting and tongue-thrusting also increase the frequency and degree of root resorption (Odenrick and Brattstrom 1983, 1985; Harris and Butler 1992).
- The type of tooth movement: The opponents of the Begg technique pointed out that the tipping and subsequently torquing of the upper anterior teeth, as referred to as 'round tripping', causes root resorption (Stuteville 1938; Ten Hoeve and Mulie 1976; Mollenhauer 1987). On the other hand, the opponents of the edgewise technique refer to the heavy forces of extra-oral appliances, such as class II elastics, and rectangular archwires as inducing root resorption (Reitan 1960).

2.5 CLASS II MALOCCLUSION

According to Bishara (2006) Class II malocclusion is the most common type of malocclusion, and is of main interest to the practicing orthodontists as it composes a higher percentage of the cases that they treat. Class II div 2 in particular, is one of the easiest malocclusions to treat with the Tip-Edge technique as opposed to treating with the edgewise technique.

The introduction of standardized cephalometric radiographs and their widespread use in clinical orthodontics in the second half of the twentieth century permitted further appreciation of the dental and skeletal features that may be associated with individuals who have Class II malocclusions (Bishara 2001).

Class II malocclusions can occur as a result various underlying skeletal problems. It is possible to have a normal skeletal jaw relationship associated with a dental Class II malocclusion. In these conditions the maxillary molars have moved forward more than normal during dental development, whereas the mandibular molars have remained in a more posterior position relative to the maxillary molars. The causes of these dental Class II malocclusions can be subdivided into two groups: (1) maxillary dental protrusion and (2) mesial drift of the maxillary first permanent molars (Bishara 2001).

Maxillary dental protrusion may be confused with anteroposterior maxillary excess or midface protrusion. Although both conditions are characterized by facial convexity, maxillary dental protrusion is not a skeletal problem but a dentoalveolar one that is limited to the maxillary dental arch. The facial appearance of anteroposterior maxillary excess is a protrusion of the entire midface, whereas maxillary dental protrusion only affects the lips. Excessive overjet is a reliable feature of this dental malocclusion, and there may be generalized maxillary spacing associated

with the protruded maxillary incisors. The mandible and mandibular dentition are in a normal anteroposterior position (Bishara 2001).

McNamara (1981) compared findings for two measurements from the same group of mixed dentition patients, one method (U1 to A-Po) sensitive to mandibular position and a second method (U1 to Point A Vertical) that is independent of mandibular position. The comparison of results was startling. With A-Po as the orientation line, maxillary incisors appeared protrusive 75% of the time; with Point A Vertical for orientation, the maxillary incisors were judged protruded only 20%, neutral 50%, and retruded 30% of the time McNamara (1981).

Mesial and occlusal drift of the permanent first molars occurs if there is loss of mesial proximal contact with the second primary molars from congenital absence, extraction, dental caries or ankylosis. If left untreated, the maxillary first permanent molar assumes a more mesial position, resulting in a Class II permanent molar relationship if the mandibular arch is unaffected. This dental Class II relationship may be unilateral or bilateral and, if there is no incisor protrusion, results in a normal overjet with crowding of the maxillary arch caused by the loss of space in the arch perimeter (Bishara 2001).

McNamara (1981) evaluated the variation in the position of the mixed dentition mandible in relation to cranial structures by way of two cephalometric measures: pogonion to the nasion perpendicular and the SNB angle. These measures indicate that a deficiency in the anteroposterior position of the mandible is the main cause for Class II malocclusion, with about 60% of the patients demonstrating mandibular skeletal retrusion (McNamara 1981).

Bishara et al., (1988) suggest that in subjects with Class II occlusal features in the deciduous dentition, treatment should be started as soon

as the clinician and the patient are ready for treatment to begin. The first of these trials (Keeling et al., 1998), conducted at the University of Florida, included the comparison of children randomly assigned to one of three groups: control, bionator, and headgear (cervical or high-pull) with an anterior biteplane. The results demonstrated that the use of the headgear or the bionator did not significantly affect maxillary growth but both appeared to enhance mandibular growth with this effect remaining stable one year following treatment. The dental changes that occurred with the treatment, namely retraction of maxillary teeth and protraction of mandibular teeth, did not appear to be stable following removal of the appliances.

The second prospective randomized clinical trial has been taking place at the University Of North Carolina (UNC). The progress report on the benefits of two-phase vs. one-phase in treating Class II malocclusion was published in 1988 by Tulloch et al. A somewhat smaller sample of children was assigned randomly to one of three groups: control,, bionator, and combination headgear. Their findings suggested that treatment with either headgear or bionator would be imperative in improving the relationship of the jaws in children (75 percent).

The second phase of their study was mainly to test whether these changes represented long-term differences or not. It is evident from their results that the skeletal changes that take place with early treatment are unsustainable. They also noted that the number of patients who required extractions of permant teeth was more in the bionator group than in the headgear or control group. They then concluded that for children with moderate-to severe Class II malocclusion, early (phase I) treatment followed by conventional orthodontics later on (phase II) does not produce skeletal or occlusal relationships that differ substantially from those produced by phase II treatment alone. Also that treatment time has no influence on the final results.

The study by Tulloch et al. (2004) on the outcomes in a 2-phase randomized clinical trial of early Class II treatment indicate that early treatment should not be thought of as an efficient way to treat most Class II children. The decision for early treatment should be based on special indications for each child.



2.6 CLASS II ELASTICS

In the literature, class II elastics are also referred to as intermaxillary elastics. Thus, these terms will be used interchangeably. In orthodontic treatment, these elastics are mainly used for the traction of teeth.

Class II elastics are said to be the auxiliary forces that can serve as active elements in a fixed appliance system (Uzel et al., 2007). According to several authors, these elastics have been used in the correction of Class II malocclusion since the early days of orthodontic treatment (Payne, 1971; Ellen et al., 1998; Graber and Vanarsdall, 2000; Reddy et al., 2000).

According to Langlade (1978); Edwards (1983); Van der Linden (1989); Philippe (1995) and Ellen et al. (1998), some undesirable effects tend to occur, but these effects are mainly dependent on their vertical force vectors. The vertical force vectors can extrude the mandibular molars and maxillary incisors, hence resulting to the rotation of the occlusal plane (Uzel et al., 2007).

Because the force vectors differ according to the area where they are applied, different methods have been recommended to overcome the negative side effects. Also, various timing and application methods have been proposed for different mandibular vertical growth patterns by different authors (Levin, 1987; Philippe, 1995). Short elastics have been recommended in order to prevent lower molar extrusion, and the use of segmental techniques has also been recommended in order to prevent upper canine extrusion (Schudy, 1965; Ricketts, 1980; Schudy, 1992).

The principle of reciprocal forces applies to this tooth-borne type of anchorage (Sassouni & Forrest, 1971). It is termed as Class II elastic

traction when the pulling force is from the maxillary incisor segment to the mandibular molar segment and Class III elastic traction when the force from the mandibular incisor segment to the maxillary molar segment. The forces are oblique and can be divided into their horizontal and vertical vectors.

It is common knowledge that the use of Class II or Class III elastics is a useful approach in anchorage conservation and maintaining control of the cant of the occlusal plane (Sassouni & Forrest, 1971).

However, Graber et al. (1997) points out that in an attempt to correct sagittal problems with Class II elastics, vertical changes are induced by the elevation of the lower molars with the net effect of opening the mandibular angle. Point B is then moved into a more retruded position.

Because normally only a 2.5mm annual vertical height change occurs, not much extrusion of the molar teeth needs to occur to create unfavorable mandibular rotation with Class II elastic traction and conventional cervical extra-oral traction directed against the maxillary first molars with a facebow.

Stockli & Teuscher (1982) demonstrated this change. The eruption of the upper and lower molars by 1 mm resulted in an opening of the Y-axis by 2.5° , a retrusions of the chin point, and the reduction of the SNB angle by 2.5° . As he observed, the claim of a poor growth pattern is often more likely because of an iatrogenic deflection of the natural growth path.

The effect of class II elastics on the molars was also shown in a study that was conducted by Nelson et al. (2000), where he looked at the cases treated with Begg's technique as compared to those treated with the Herbst appliance. It was concluded from this study that there were unfavourable vertical changes which were more pronounced in the group treated with class II elastics, i.e. Begg's technique. On the hand, the cases that are treated with the Tip-Edge technique show very minimal changes mainly because they utilize class II elastics of very light forces (2oz), as compared to the forces used in the edgewise as well the Begg's technique.



2.7 EXTRACTION OF PREMOLARS IN CORRECTING CLASS II MALOCCLUSION

Extraction of teeth for orthodontic reasons is recorded in the literature from the middle of the eighteenth century. The writings of John Hunter, Fox, Fauchard and, later, Kingsley, show that some of the principles employed today were used at that time (Tulley, 1959). To extract or not to extract has been a key question in planning orthodontic treatment 100 years. In orthodontics, there are two major reasons to extract teeth:

1. To provide space to align the remaining teeth in the presence of severe crowding, and
2. To allow teeth to be moved (usually, incisors to be retracted) so that protrusion can be reduced or so skeletal Class II or Class III problems can be camouflaged. The alternative to extraction in treating dental crowding is to expand the arches (Proffit, 2007).

Angle (1900) in the sixth edition of his book "Malocclusion of the Teeth", described extractions for the relief of crowding and in the treatment of various types of malocclusion. The seventh edition of his book completely refuted his earlier writings and since then he has always been considered the leading exponent of non-extraction technique. Angle (1907) believed that everyone had the capacity to have 32 teeth in functional occlusion, and therefore believed in expansion.

This was however criticized by Case in 1911 who believed in extractions in relieving crowding and thus aid in stability (Case, 1964). When Charles H. Tweed graduated from an improvised Angle course given by George Hahn in 1928, he was 33 years old and Angle was 73. Angle was bitterly disappointed by the reception that had been accorded the edgewise appliance. He was infuriated and bitter about the modifications that were being made by several of his graduates (namely Spencer Atkinson). To

him it was obvious that something had to be done if the edgewise appliance was to survive intact. Angle decided that an article describing the appliance lead be published in Dental Cosmos (Graber et al., 2005).

On August 11, 1930, Angle died at the age of 75. In 1932 Tweed published his first article which was titled "Reports of Cases Treated with Edgewise Arch Mechanism". Tweed also held to Angle's firm conviction of non-extraction. This conviction lasted for only 4 short years. What Tweed began to observe in his patients during retention was discouraging to him, such that he almost gave up orthodontic practice. He knew he had the appliance, and he knew he had the ability, but his results were unstable and unsatisfactory. He then selected his failures, extracted four first premolar teeth, and retreated the patients. He did this without charging a fee. In 1936 Tweed delivered a lecture to the membership of the Angle Society and subsequently published his first paper on the extraction of teeth for orthodontic purposes (Pollock, 1964).

Tweed was crushed by the response he got from the members of the Angle Society, but he returned home determined to continue his research (Graber et al., 2005). He worked even harder than before. By 1940, he had produced case reports, with four sets of records, of 100 consecutively treated patients, first treated with non-extraction methods and later with extraction. He managed to get himself on the program of the next meeting of the Angle Society in Chicago, where he would presented a paper and displayed his case reports (Graber et al., 2005).

Raymond Begg in Australia (Begg, 1954), another of Angle's students, independently of Tweed but simultaneously, looked at the dentition of the Aborigines in Australia, who had a low incidence of dental crowding, and came to the conclusion that the increase in malocclusion in the Western societies was due the refinement of the diet, which led to a lack of attrition of the teeth, also concluded that non-extraction treatment was unstable.

Begg (1954) therefore advocated extraction therapy to remove the same amount of tooth substance that our diet and attrition would have done for us. Like Tweed, he modified the Angle-designed appliance he was using. The appliance system that he developed is now called the Begg appliance and was thus designed to be used with extraction-based treatments. Also, with the advent of cephalometric radiology, the consensus view was that facial growth was genetically determined and that orthodontics had little or no effect on the outcome. So the orthodontist came to operate within the bounds of genetic control and accept the discrepancies of jaw position as well as overcoming crowding.

Premolars are often ideal for the relief of both anterior and posterior crowding. The choice of extraction between the first or second premolars depend on various factors, such as, the degree of crowding, the site where crowding is, the anchorage requirements, the overjet and overbite (Travess et al., 2004).

The first premolars are located strategically, to allow for ease of incisor retraction as well as for symmetrical retraction (Brandt and Safirstein, 1975). They are also positioned near the centre of each quadrant of the dental arch, and are therefore normally near the site of crowding. Another important factor is that first premolars can be replaced by the second premolars, which are much the same shape, and which makes a similar contact with the canine. Thus, the loss of the first premolar need not affect the quality of the contacts between the teeth (Forster, 1990).

Tulley (1959) has stated that the extraction of upper first premolars has always been one of the methods for treating a Class II Division I malocclusion, particularly where there is considerable overjet. The upper arch is shortened and the overjet reduced by retracting the canines followed by retraction of the incisors. Lower first premolars should not be extracted in Class III cases except where the lower crowding is very

severe and the discrepancy in arch relationship not very marked.

Tulley (1959) further stated that the extraction of first premolars should not be carried out until the reduction of the overjet is well under way. In the treatment of Class II Division 2 malocclusion the extraction of the upper first premolar to allow retraction of canines and alignment of laterals is practiced but tends to leave some residual spacing. Lower first premolar extractions should certainly not be carried out in cases with this type of deep overbite as it may well cause further collapse and the overbite become traumatic to the lower labial and palatal soft tissues.

The removal of the second premolar for the relief of crowding is usually undertaken when the tooth is itself malpositioned through crowding. As it erupts after the first premolar and first permanent molar, it may be completely excluded from the dental arch. If removed, it can satisfactorily be replaced by the first premolar unless the first permanent molar has tilted or rotated forward, in which case the contact between the two teeth will not be correct (Forster, 1990). There are certain indications for the extraction of second premolars (Brandt & Safirstein, 1975; Bennett & McLaughlin, 1998; Tulloch, 1978).



3. AIMS AND OBJECTIVES
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The aim of this study was:

To compare cephalometric changes in skeletal and dento-alveolar parameters of cases that were treated by two different orthodontic techniques.

The objectives of the study were:

- To calculate the pre-treatment and post-treatment differences of both Tip-Edge and edgewise techniques by looking at the skeletal and dento-alveolar measurements
- To compare pre- and post-treatment cephalometric variables of cases treated with Tip-edge and edgewise techniques by looking at the skeletal and dento-alveolar measurements, and
- To assess if there were any significant differences in various cephalometric variables of these cases.



4. MATERIALS AND METHODS

This project involved a cephalometric comparison of Class II extraction cases that were treated with Tip-Edge and Edgewise techniques. The materials and methods for the study under consideration are discussed under the following headings:

- 1. Study Design.**
- 2. The Study Population.**
- 3. Subject Selection.**
- 4. Materials and Methods.**
- 5. Measurements.**
- 6. Statistical Analysis.**
- 7. Ethical Statement.**



4.1 STUDY DESIGN

This was a comparative, retrospective cohort study. Thirty Tip-Edge and thirty edgewise treated cases were selected. These had class II malocclusions, as well as extraction of four first premolars and were treated with Class II elastics.

4.2 STUDY POPULATION

Study population was a total of 60 patients, one half was treated by an orthodontist in private practice (Tip-Edge cases) and the other half was taken from the cases that had been treated at the University of the Western Cape (edgewise cases).

4.3 SUBJECT SELECTION

4.3.1.1 Inclusion Criteria

- All cases with class II malocclusion, with an ANB of 5° and more were included.
- Cases had an overjet and overbite of 4mm or more.
- All cases had extraction of all four first premolars.
- Both pre- and post-treatment lateral Cephalometric radiographs were available.

4.3.1.2 Exclusion Criteria

- Cases treated with Headgears or any other distalizing mechanics were excluded.

- Cases where orthognathic surgery was required, and syndromic cases were excluded.

4.4 MATERIALS AND METHODS

Pre- and post-Cephalometric radiographs were obtained from these cases. These were divided into two groups. Group A was the pre-treatment cephalometric measurements and Group B was the post-treatment measurements. This was done for both groups. Various points and planes were measured and recorded (see Appendix A). Then both groups were compared for both techniques. The landmarks used were digitized using a Dolphin 10.5 Imaging and Management solutions program.

4.5 MEASUREMENTS

See Appendices A and B



4.6 STATISTICAL ANALYSIS

The measured values for the pre- and post-treatment samples under study of both the Tip-Edge and Edgewise techniques were collected and placed in data tables. Two separate sheets of data tables were entered for cross-checking the accuracy of the data. Descriptive statistics (mean, median, standard deviation, range) were calculated from the observed values for each measurement.

The software SAS v9 (SAS Institute Inc., Cary, NC, USA) was used for analysis. Secondary analyses were done using F-tests to compare variances and analysis of covariance to adjust for possible effects of different ages and treatment times. Initially the results were subjected to

the student t tests (parametric methods) but the analysis of the data obtained was complicated by several factors, namely:

1. Some extreme values made the measured changes abnormal, according to the normal curve (also called the bell-shape or Gaussian curve) of distribution.
2. The changes might have been related to the amount of treatment time which was not the same for all patients.
3. Changes might have been related to the age of the patient as there was a wide range of ages.
4. The variability in measurements appeared to differ for the two techniques.

In the absence of these issues we could have used a simple two-sample t-test to compare the responses to the two techniques. In view of the non-normality and the different variability for the groups, nonparametric methods were used for the primary analysis. The nonparametric methods used were the Wilcoxon Rank Sum test (for comparing location), the Ansari-Bradley test (for comparing variability), the Kolmogorov-Smirnov test (for comparing entire distributions), and the Spearman Rank Correlation (for examining associations).

The Null Hypothesis of the study was that there were no significant differences between the pre- and post-treatment cephalometric variables in cases treated with Tip-Edge and edgewise techniques,

4.7 ETHICAL STATEMENT

This proposal was presented to the ethical and research committee of the University of the Western Cape for approval. Permission to use the

records for this study was requested from the University of the Western Cape. These records will remain anonymous.





Some graphs are shown below to allow one to visually compare the groups (see Figures 2-19). The descriptive statistics for all relevant variables is presented in Table 1-6. These are shown for all patients combined and by Technique. A table showing the proportions of males/females receiving each technique is also given. (There was not a significant difference in these proportions). **NOTE:** Please refer to Appendix C for the definitions of variables used. The Null Hypothesis of this study was rejected.



TABLE 1: The Descriptive Statistics for both techniques combined
The MEANS Procedure

Variable	Label	N	Mean	Median	Std Dev	Minimum	Maximum
age		60	15.7785	13.8500	6.3998	11.4000	42.7000
rx_time		60	1.9828	2.0000	0.4405	1.1100	2.8000
diff1		60	1.8367	1.5500	5.4556	-19.6000	19.8000
diff2		60	2.5783	2.1500	6.3632	-19.3000	26.4000
diff3		60	3.3533	3.3000	6.9936	-19.2000	27.2000
diff4		60	4.6167	4.0000	2.3223	1.0000	10.0000
diff5		60	0.0550	-0.5500	7.1243	-22.5000	24.6000
diff6		60	-1.8533	-1.8500	2.0332	-7.3000	2.2000
diff7		60	0.8567	0.3500	8.7279	-29.0000	32.5000
diff8		60	-1.3350	-1.5000	2.2701	-7.0000	6.3000
diff9	ob1- ob2	60	3.4483	3.4500	1.6005	-1.0000	7.0000
diff10	oj1-oj2	60	3.2633	3.1500	1.4179	-0.4000	8.5000
diff11	anb1- anb2	60	2.2300	2.2000	0.9891	0.4000	4.5000
t1		60	6.0669	4.3364	6.5585	0.2828	33.0000
t2	Total dist U6	60	7.7143	6.9466	5.1859	2.0000	27.3649
t3		60	5.1534	3.3008	5.6016	0.5099	25.1231
t4	Total dist L6	60	5.5393	3.1833	7.2584	0.5000	33.1050
	Total dist U1						
	Total dist L1						

TABLE 2: The Descriptive Statistics for each technique separately
The MEANS Procedure

Technique	N Obs	Variable	Label	N	Mean	Median	Std Dev	Minimum	Maximum
1	30	age		30	17.783	14.150	8.4873	11.4000	42.7000
		rx_time		30	1.9347	1.9000	0.4465	1.1100	2.8000
		diff1		30	2.2000	1.4000	7.4253	-19.6000	19.8000
		diff2		30	2.2633	1.3000	8.4705	-19.3000	26.4000
		diff3		30	3.6267	3.3500	9.6438	-19.2000	27.2000
		diff4		30	4.0667	3.0000	2.3332	1.0000	10.0000
		diff5		30	0.8667	0.0500	9.7440	-22.5000	24.6000
		diff6		30	-	-1.5500	1.9835	-7.3000	1.9000
		diff7		30	1.9233	0.2500	12.154	-29.0000	32.5000
		diff8		30	1.3900	-0.9500	2.6440	-7.0000	6.3000
		diff9	ob1-ob2	30	-	3.4000	1.8098	-1.0000	7.0000
		diff10	oj1-oj2	30	0.7567	3.0000	1.4081	-0.4000	5.9000
		diff11	anb1-anb2	30	3.4833	3.0000	1.4081	0.4000	4.5000
		t1		30	3.1300	1.9000	1.0669	0.2828	33.0000
		t2	Total dist U6	30	2.0100	3.4270	8.7341	2.0000	27.3649
		t3	Total dist L6	30	7.6730	6.9593	6.7028	0.5099	25.1231
		t4	Total dist U1	30	9.0236	3.2296	7.4388	0.5000	33.1050
	Total dist L1		6.8223	2.6890	9.7661				
			7.7375						

Technique	N Obs	Variable	Label	N	Mean	Median	Std Dev	Minimum	Maximum
2	30	age		30	13.7737	13.2000	1.7251	11.5000	20.1000
		rx_time		30	2.0310	2.0500	0.4366	1.1100	2.8000
		diff1		30	1.4733	1.7500	2.2687	-2.6000	6.0000
		diff2		30	2.8933	3.3000	3.2284	-6.3000	8.4000
		diff3		30	3.0800	3.3000	2.5198	-1.2000	8.0000
		diff4		30	5.1667	5.0000	2.2141	2.0000	9.0000
		diff5		30	-	-1.0500	2.6366	-5.6000	5.5000
		diff6		30	0.7567	-1.9500	2.1134	-6.7000	2.2000
		diff7		30	-	-	2.5813	-4.8000	5.7000
		diff8		30	1.7833	0.6500	1.6739	-4.5000	1.9000
		diff9	ob1-ob2	30	0.3233	-2.2000	1.3905	1.3000	6.6000
		diff10	oj1-oj2	30	-	3.4500	1.4390	1.3000	8.5000
		diff11	anb1-anb2	30	1.9133	3.3500	0.8673	0.9000	4.4000
		t1		30	3.4133	2.3500	2.4272	1.0000	9.4366
		t2	Total dist U6	30	3.3967	4.5221	2.4982	2.0100	10.8167
		t3	Total dist L6	30	2.4500	6.7243	1.6550	0.5099	7.8032
		t4	Total dist U1	30	4.4607	3.3008	1.3460	0.5000	6.2650
	Total dist L1		6.4050	3.4848					
			3.4846						
			3.3412						

NOTE: Table 1 and 2 show that there is a big difference between the mean ages of the two groups. Treatment time did not differ that much. Technique 1 (Tip-Edge) had a large standard deviation of diff1, diff2, diff3, diff5, diff7 and t1-4. Technique 2 (edgewise) had a narrow range of values.

Table 3: The Frequency Procedure

Frequency Row Pct	Table of technique by gender			
	technique	gender		
		F	M	Total
1	14 46.67	16 53.33	30	
2	18 60.00	12 40.00	30	
Total	32	28	60	

TABLE 4: Statistics for Table of technique by gender

Statistics for Table of technique by gender

Statistic	DF	Value	Prob
Chi-Square	1	1.0714	0.3006
Likelihood Ratio Chi-Square	1	1.0747	0.2999
Continuity Adj. Chi-Square	1	0.6027	0.4376
Mantel-Haenszel Chi-Square	1	1.0536	0.3047
Phi Coefficient		-0.1336	
Contingency Coefficient		0.1325	
Cramer's V		-0.1336	

Sample Size = 60

This table shows that there is no statistically significant difference between the two groups for gender (P value of 0.3006).

TABLE 5: The Correlation Procedure of Outcomes with Treatment time and Age, Technique=1

2 With Variables:	rx_time age
15 Variables:	diff1 diff2 diff3 diff4 diff5 diff6 diff7 diff8 diff9 diff10 diff11 t1 t2 t3 t4

Spearman Correlation Coefficients, N = 30
Prob > |r| under H0: Rho=0

	diff 1	diff 2	diff 3	diff 4	diff 5	diff 6	diff 7	diff 8	diff 9	diff 10	dif f11	t1	t2	t3	t4
rx_time	-	-	-	-	-	-	-	-	-	0.4	0.0	0.1	-	-	0.0
	0.0	0.2	0.3	0.2	0.1	0.1	0.3	0.2	0.0	0.71	0.92	0.95	0.0	0.0	0.69
	50	49	40	68	87	62	05	44	46	36	54	66	63	87	03
	35	03	63	91	29	64	70	71	30				43	63	
	0.7	0.1	0.0	0.1	0.3	0.3	0.1	0.1	0.8	0.08	0.6	0.3	0.0	0.7	0.7
	91	84	65	50	21	90	00	92	08	6	7	1	39	45	0
	6	5	5	7	7	5	4	5	1				2	2	
age	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	-	-	0.2	0.2	0.3	0.3	0.5
	54	95	15	34	93	77	54	31	0.1	0.1	62	25	69	47	34
	55	03	36	81	81	83	65	39	13	24	50	41	38	57	71
	0.7	0.6	0.9	0.8	0.6	0.3	0.4	0.8			0.1	0.2	0.0	0.0	0.0
	74	17	35	55	21	47	14	69	0.5	0.5	61	31	44	59	02
	6	4	8	1	9	1	5	2	49	11	1	1	5	8	3
									5	8					

TABLE 6: The Correlation Procedure of Outcomes with Treatment time and Age, Technique=2

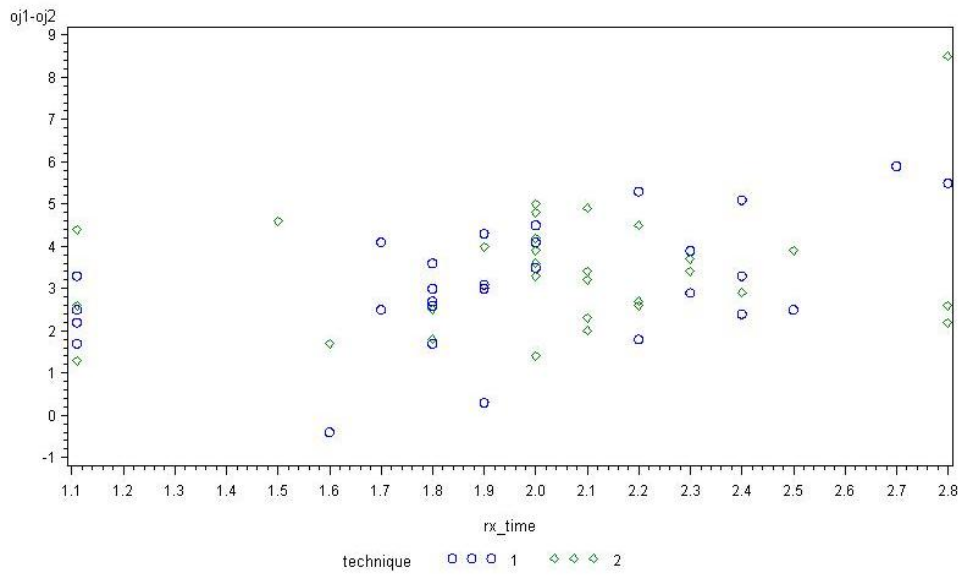
2 With Variables:	rx_time age
15 Variables:	diff1 diff2 diff3 diff4 diff5 diff6 diff7 diff8 diff9 diff10 diff11 t1 t2 t3 t4

Spearman Correlation Coefficients, N = 30
Prob > |r| under H0: Rho=0

	diff 1	diff 2	diff 3	diff 4	diff 5	diff 6	diff 7	diff 8	diff 9	diff 10	diff 11	t1	t2	t3	t4
rx_time	-	-	0.0	-	-	-	0.0	-	0.0	0.1	0.0	-	-	0.2	0.1
	0.0	0.2	0.74	0.1	0.2	0.0	0.36	0.0	0.31	0.02	0.91	0.1	0.0	0.77	0.48
	54	19	63	63	27	08	86	16	36	71	85	53	54	09	55
	85	56		77	42	43		08				04	62		
			0.6				0.8		0.8	0.5	0.6			0.1	0.4
	0.7	0.2	0.95	0.3	0.2	0.9	0.46	0.9	0.69	0.89	0.29	0.4	0.7	0.38	0.33
	73	43	1	87	26	64	7	32	3	1	3	19	74	2	4
	5	7		2	8	7		8				4	4		
age	-	-	-	-	-	0.3	-	0.2	-	0.0	0.2	-	-	-	-
	0.1	0.2	0.2	0.4	0.0	0.74	0.1	0.58	0.1	0.30	0.58	0.1	0.4	0.3	0.4
	10	44	40	82	27	25	63	78	14	78	03	88	89	19	47
	85	40	88	46	66		47		87			65	52	99	10
						0.0		0.1		0.8	0.1				
	0.5	0.1	0.1	0.0	0.8	0.41	0.3	0.67	0.5	0.71	0.68	0.3	0.0	0.0	0.0
	59	93	99	06	84	6	88	3	45	7	6	18	06	84	13
	8	1	7	9	6		1		6			1	0	7	2

NOTE: Table 5 and 6, show the correlations of the outcomes with age and treatment time for both techniques. The significant correlations for Technique 1 are: Diff 10 (rx_time), t2 and t4 (age). For Technique 2 are: Diff 6, t2 and t4 (age). These correlations were statistically significantly different.

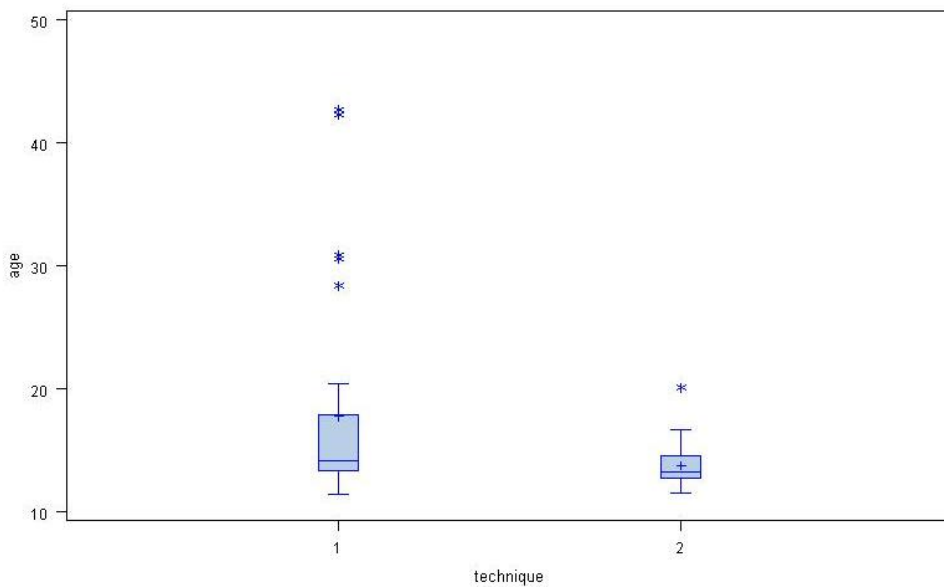
Fig 2: The Relationship between some Outcomes and RX_Time or Age



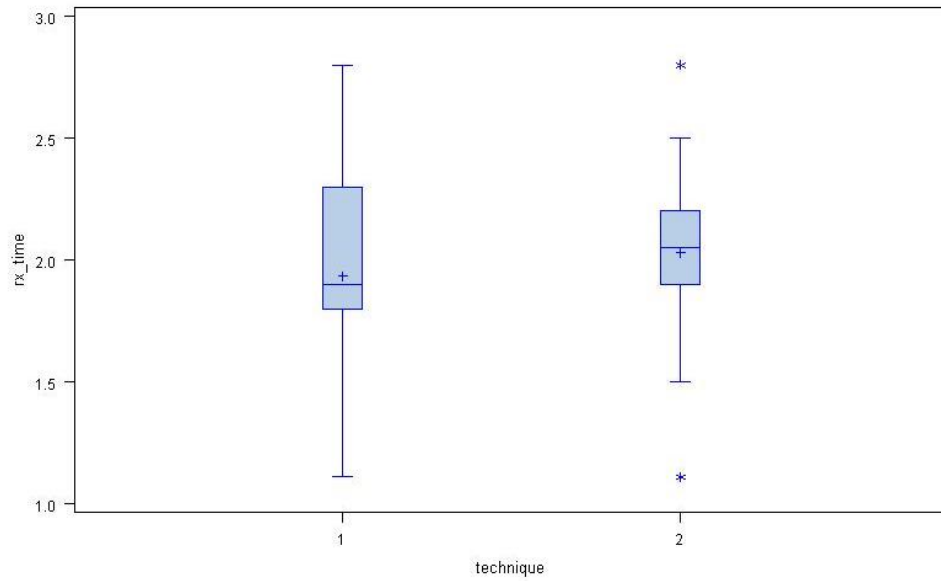
NOTE: There is no significant difference in overjet between the two techniques



Fig 3: Comparison of Techniques vs. Age



NOTE: There is a big variation for mean ages in Technique1.

Fig 4: Comparison of Techniques vs. rx_time

NOTE: Mean changes in treatment time are similar for both techniques.

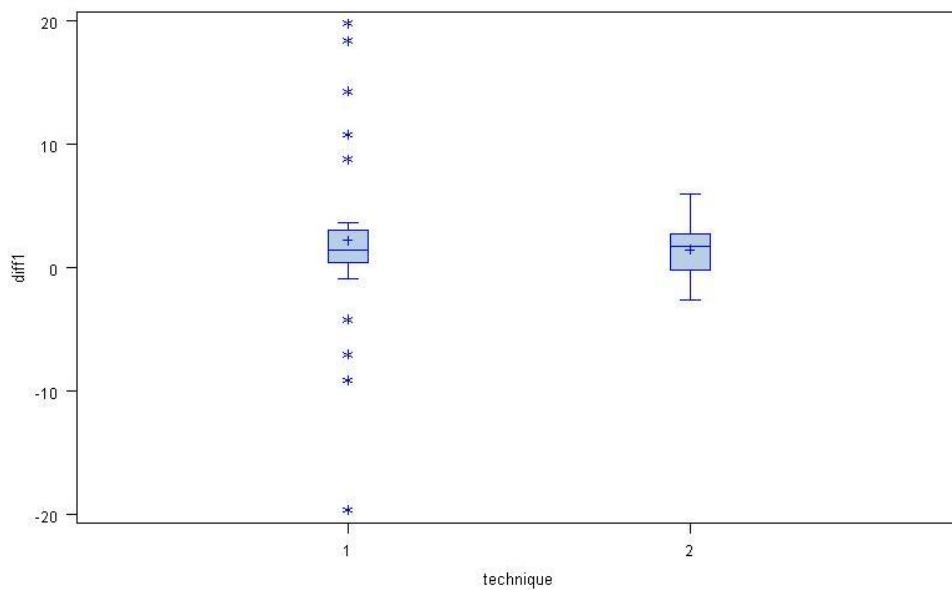
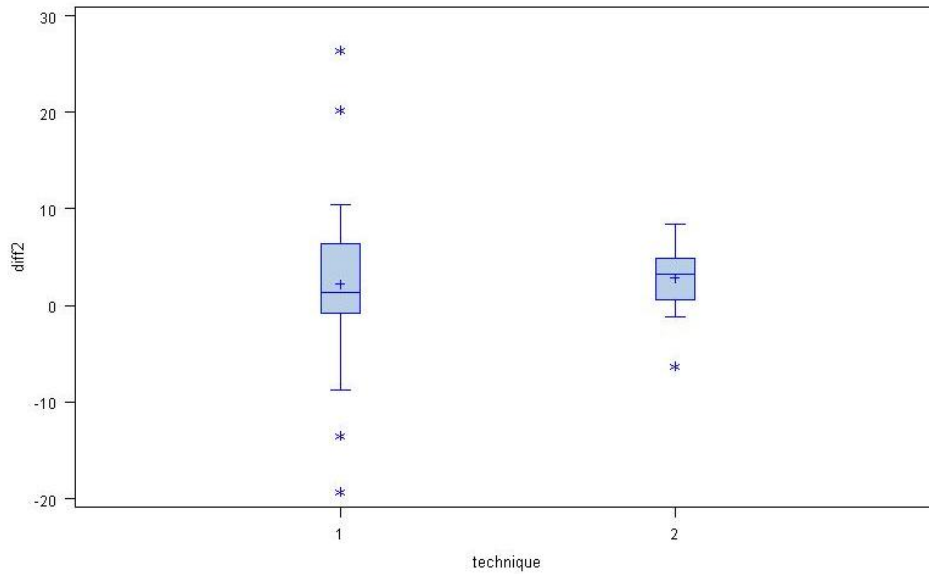
**Fig 5:** Comparison of Techniques vs. diff (Upper first molar vertical movement)

Fig 6: Comparison of Techniques vs. diff2 (Upper first molar horizontal movement)



NOTE: Fig 5 and 6 show more variation in different tooth movements for Technique 1.



Fig 7: Comparison of Techniques vs. diff3 (Lower first molar vertical movement)

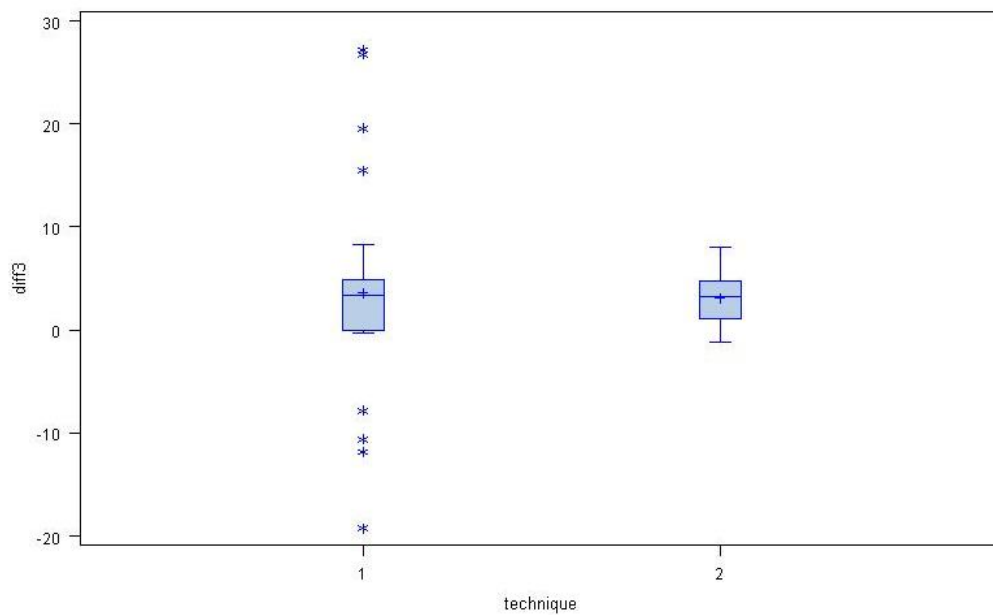
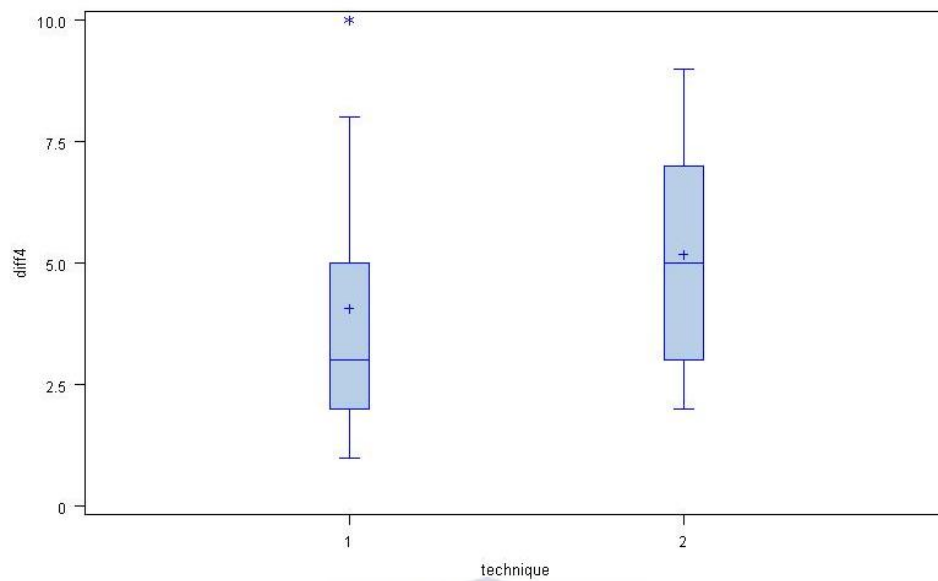


Fig 8: Comparison of Techniques vs. diff4 (Lower first molar horizontal movement)



NOTE: In Fig 7& 8, there is more vertical movemet in Technique 1. The horizontal movement is similar in both Techniques.



Fig 9: Comparison of Techniques vs. diff5 (Upper central incisor vertical movement)

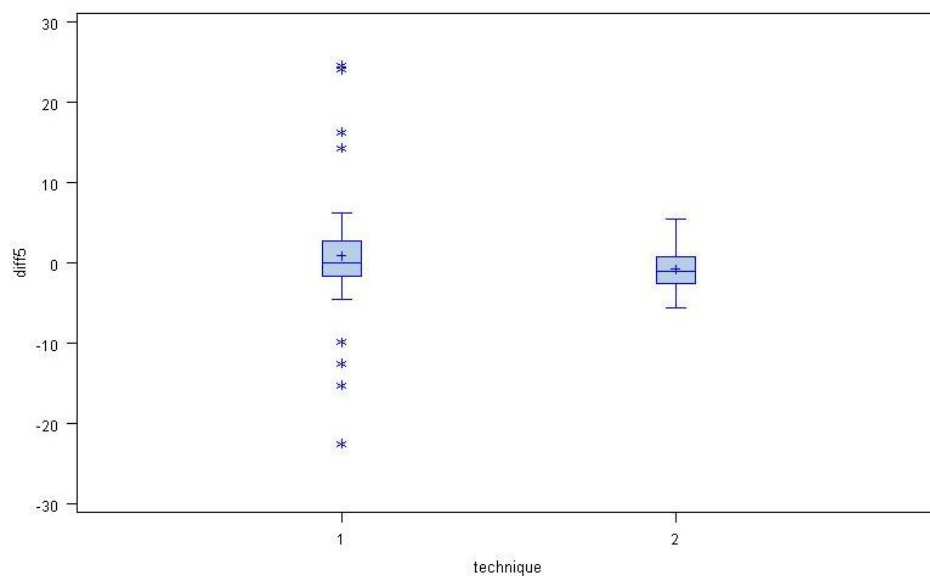
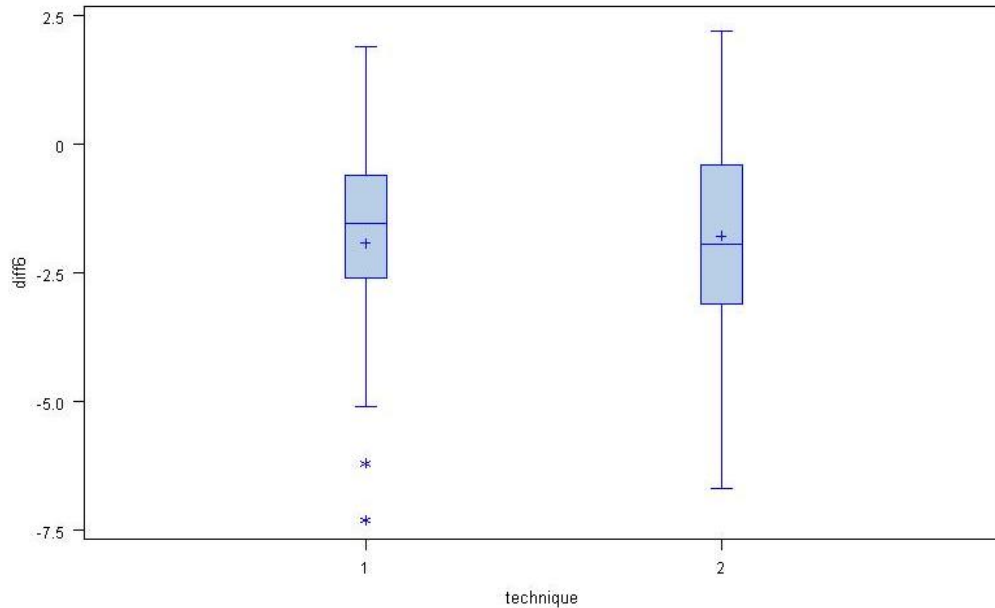


Fig 10: Comparison of Techniques vs. diff6 (Upper central incisor horizontal movement)



NOTE: In Fig 9, the mean differences are similar for diff5 in both Techniques. Fig 10 shows a greater variation in diff 6 for Technique 2.



Fig 11: Comparison of Techniques vs. diff7 (Lower central incisor vertical movement)

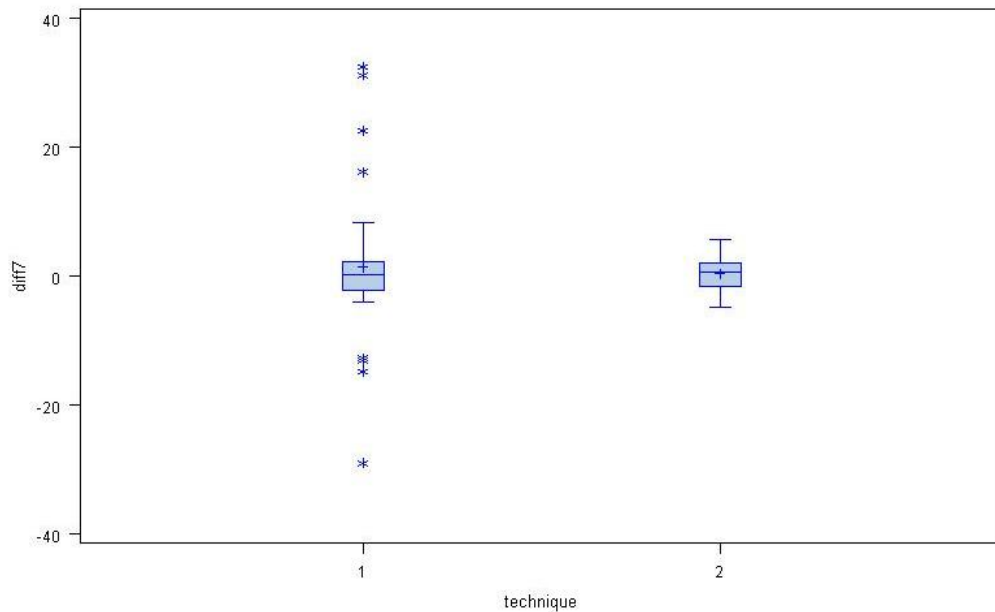
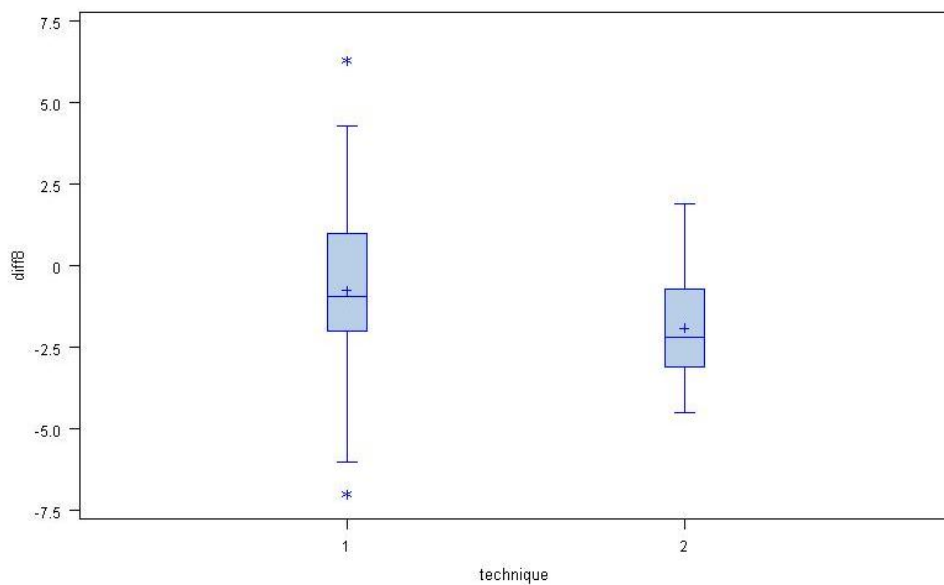


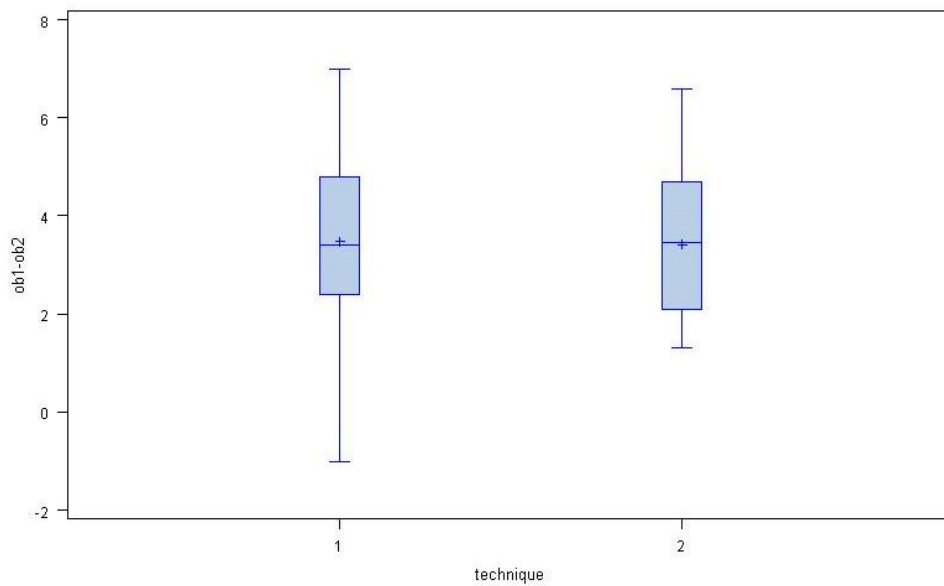
Fig 12: Comparison of Techniques vs. diff8 (Lower central incisor horizontal movement)



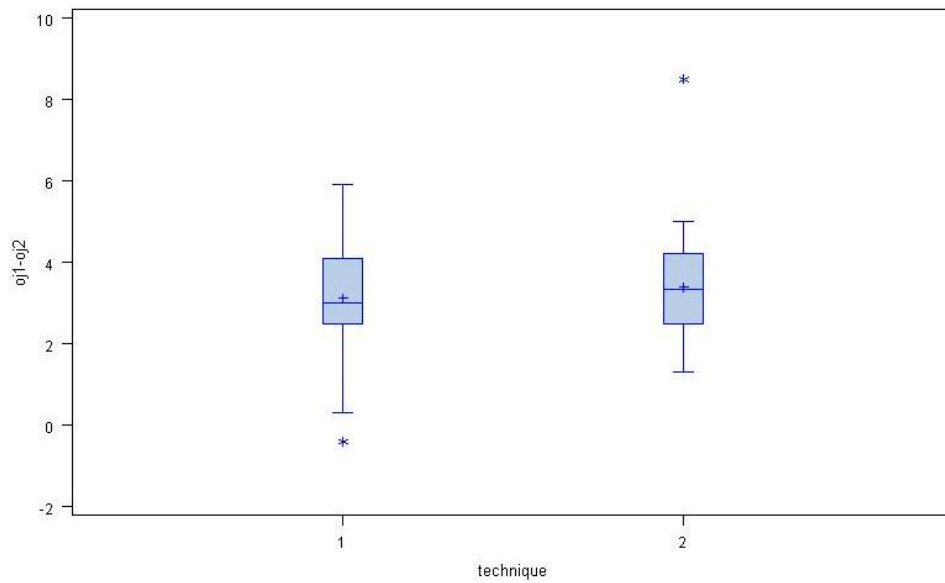
NOTE: In Fig 11, the mean changes are similar for both techniques. In Fig 12, there is more variation in tooth movement for diff 1 in Technique 1.



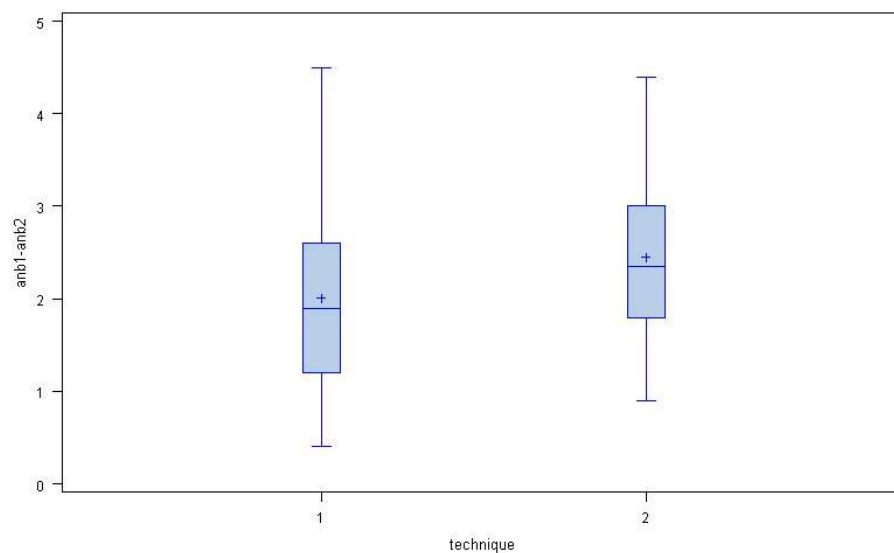
Fig 13: Comparison of Techniques vs. ob1-ob2



NOTE: There is no significant difference for overbite reduction between the two techniques.

Fig 14: Comparison of Techniques vs. oj1-oj2

NOTE: There is no significant difference in overjet reduction between the two techniques.

**Fig 15:** Comparison of Techniques vs. anb1-anb2

NOTE: There is no significant difference in the ANB changes between the two techniques.

Fig 16: Comparison of Techniques vs. Total distance of upper first molar

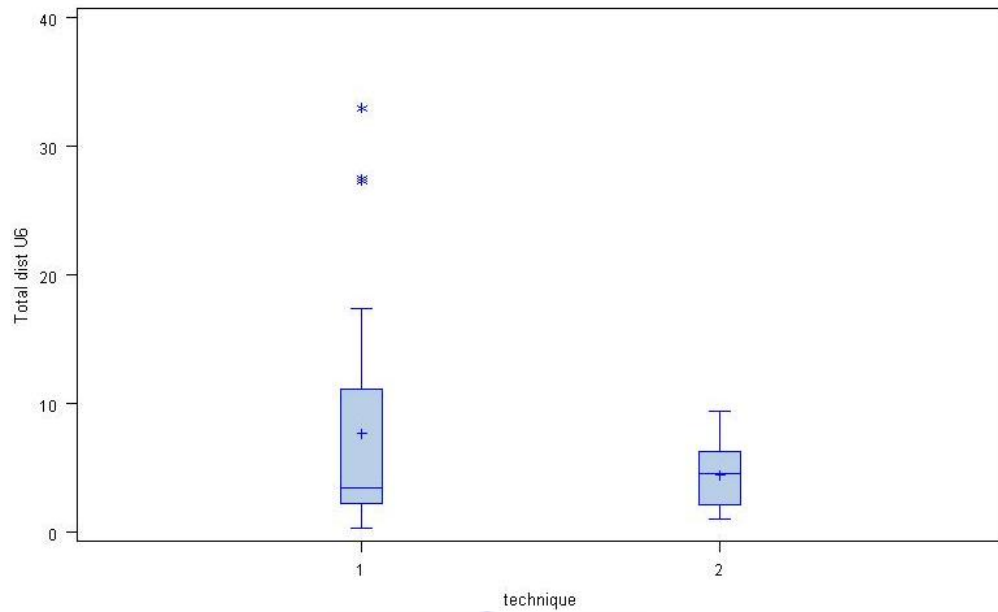


Fig 17: Comparison of Techniques vs. Total distance of lower first molar

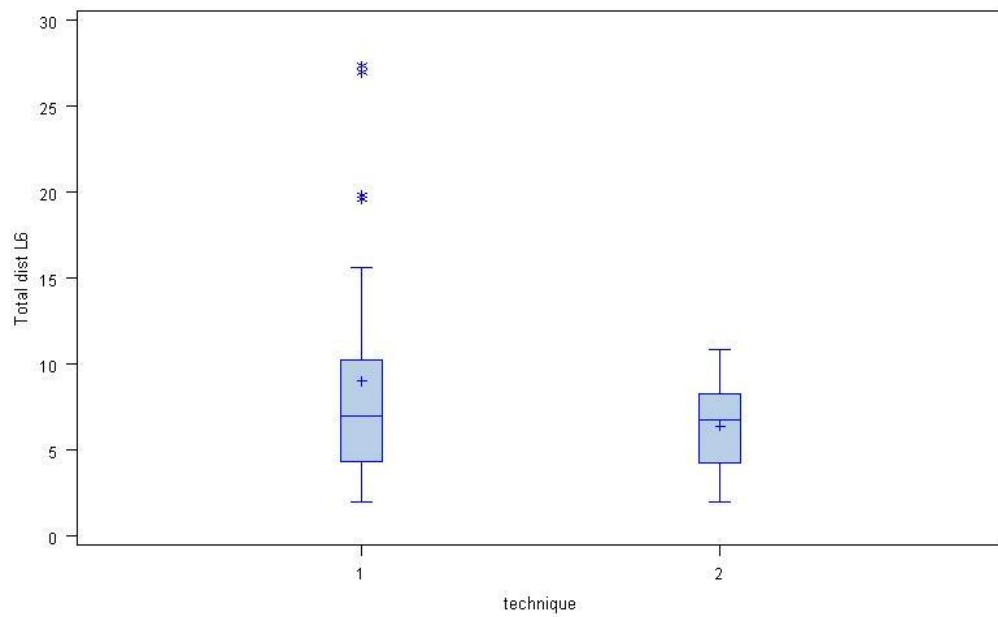


Fig 18: Comparison of Techniques vs. Total distance of upper central incisor

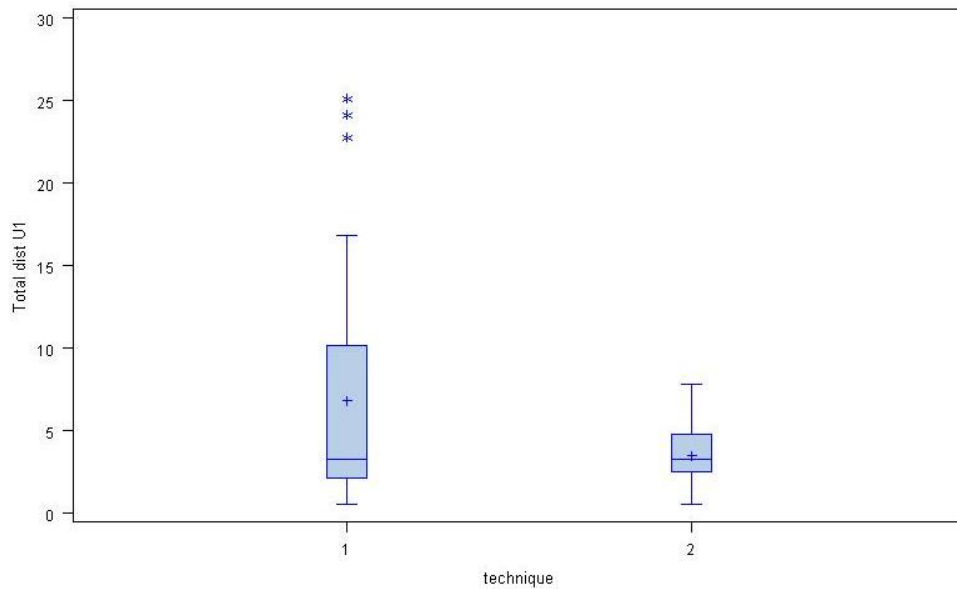
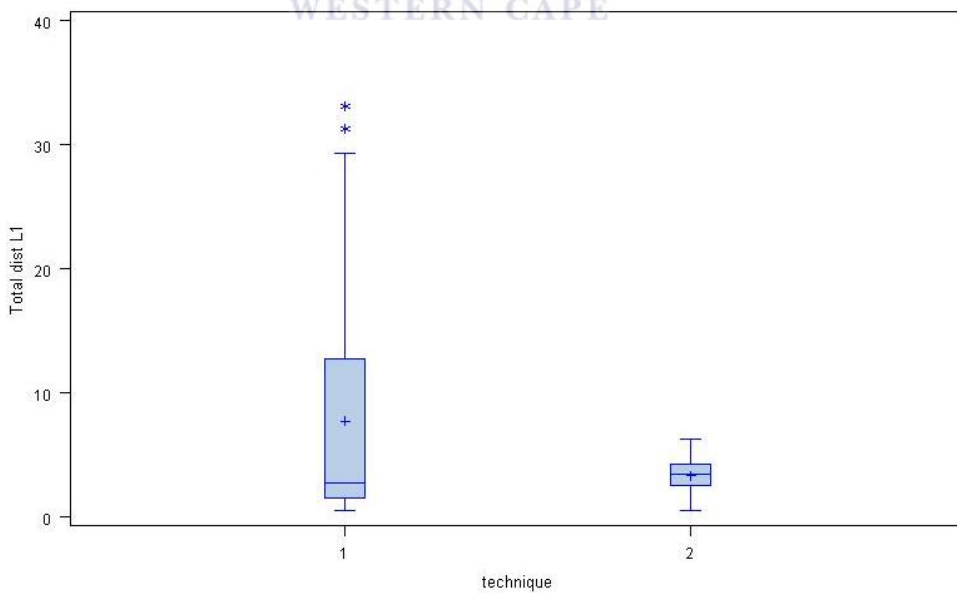


Fig 19: Comparison of Techniques vs. Total distance of lower central incisor



NOTE: Out of the total tooth movements (Fig 16-19) between the two techniques, the only significant variation is seen for the lower incisor.



The objectives of this study were to calculate and compare the pre-treatment and post-treatment differences in the variables of both Tip-Edge and edgewise techniques by looking at the skeletal and dento-alveolar measurements. Once these were obtained, the final objective was to assess if there were any significant differences found in various cephalometric variables of these cases.

In this study, we also took age, treatment time and gender into consideration. The mean age and treatment time for technique 1 (Tip-Edge) was 17.78 and 1.93 respectively, and that for technique 2 (edgewise) was 13.77 and 2.03 respectively (Table 2). This big difference in mean ages between the two techniques is notable and could affect the results obtained. When treating patients it is usually recommended that they be patients that are still growing. Table 3 shows the proportions of males/females for each technique. The Chi-square obtained for gender probability was 0.3006 (see Table 4). From these tables, it was concluded that there was no significant difference in these proportions. Table 5 and Table 6 show the correlations of the outcomes with age and treatment time for each technique.

According to the Spearman Correlation Coefficients of the age factor, it appeared that only two variables were significant, namely: Total distance moved by the lower first molar (t2) and the total distance moved by the lower central incisor (t4). Their values were 0.0445 and 0.0023 respectively for technique 1 (Tip-Edge) and 0.0060 and 0.0132 respectively for technique 2 (edgewise). Treatment time showed no significant difference for both techniques.

It was apparent that in some cases the mean and median values did not differ, but the variability may differ between groups as this was seen in the

descriptive part of our results. In comparing outcomes, it appears that there was considerably more variability when technique 1 was used, e.g. the standard deviations for T4 are 9.8 and 1.3 for the two techniques respectively (see Table 2). Similar differences can be seen for T1-T3 (see Table 2). The Ansari-Bradley test results are significant or close to significant for these outcomes.

Analysis of differences in location based on the Wilcoxon Rank Sum test was not sensitive enough to show significant differences. A secondary analysis based on a two-sample t-test with unequal variances does give some indication of differences in means for T1-T4. (E.g. $p=0.0207$ for T4.) We arrived at similar conclusions based on analysis of covariance.

From the results, it was apparent that there was strong evidence that the total distance moved was more variable for Technique 1 (Tip-Edge) than Technique 2 (Edgewise). In addition there was some evidence (though not as strong) that the total distance moved is greater for Technique 1 than Technique 2. Differences in overbite, overjet, and ANB were not significant.

There are various reasons that could explain the variability in movement that was seen in the Tip-Edge technique. The Tip-edge Technique is also known as the differential tooth movement technique (i.e. The Differential Straight-Arch Technique) (Parkhouse 1998). According to this technique, there is a simultaneous tipping of the crowns of all teeth as they move towards their newly found positions; this occurs right in the initial stage of treatment. This will then be followed by the uprighting movement of the roots in order to obtain their final axial uprighting inclinations. All these movements occur as a result of a combination of possibilities achieved initially by the use of light round stainless steel (Australian) wires, used in conjunction with the light class II elastics (Kesling 2006).

Tip-edge slots are known to be dynamic and revolutionary in action as opposed to the edgewise slots which are known to be quite static (Kesling 2006). The Tip-Edge bracket is known to have a pre-adjusted slot that is modified in order to allow for free crown tipping, which takes place mesially or distally; this happens in the presence of a straight continuous archwire (Galicia-Ramos et al., 2001). Lawson & Durning (1998) state that in the Tip-Edge bracket a range of tipping movements do occur but nevertheless extreme tipping is prevented by the “self-limiting” feature of this bracket prescription.

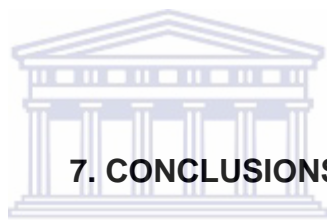
Another interesting and unique feature of the Tip-Edge bracket design that also contributes to this greater variability in movement is the fact that the archwire slot increases its vertical dimension as the tooth tips. This then allows permits the vertical space that is available for the archwire to increase from 0.022 to a maximum of 0.028 inches, due to the geometry of the bracket (Parkhouse, 2003).

Kesling (2006) states that the uniqueness of this bracket design makes it a programmed tooth movement from the beginning right to the end of the treatment, since each tooth has a predetermined initial direction of movement and final degrees of crown tip and root torque as it moves through the bracket slot. There is no other archwire slot that can be found to be programmed in this way. Therefore the versatility of this bracket slot contributes greatly in causing this variability of tooth movement as was seen from the results we got, especially referring to Fig 19, where we saw a large difference in variability of the means. This was also shown in the Ansari-Bradley test which is a nonparametric method used for comparing variability, to be statistically significant (0.0005).

Another unique feature of the Tip-edge technique is that in this technique class II elastics are worn full time, from start till finish of treatment as opposed to the edgewise technique where class II elastics are worn for a

very short time during or towards the end of treatment. It is also strongly emphasized that it is essential for the Tip-Edge technique to keep the elastic force as light as possible at all times for both sides (i.e. 2 ounces or 50gm), this force magnitude equates to about one sixth of that recommended for the edgewise technique. This is one of the main reasons why this technique can escape the unwanted effects caused by class II elastics (Parkhouse, 2003).





7. CONCLUSIONS

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Based on the findings of this study it can be concluded that:

- Age, gender and treatment time had no significant differences between the cases that are treated with either Tip-Edge or edgewise techniques.
- Vertical movement of the upper first molar was more in the edgewise technique.
- There was more vertical movement of the lower first molar in the Tip-Edge technique.
- The horizontal movements of the lower first molar as well as the vertical movement of the upper central incisor were similar in both techniques.
- There was greater horizontal movement of the upper central incisor in the Tip-Edge technique.
- There were no significant differences in the overbite, overjet and ANB changes in both techniques.
- There was a significant difference in the total distance moved by the lower molar for the Tip-Edge technique.
- It can thus be concluded that there were significant differences between these two techniques in terms of tooth movement.

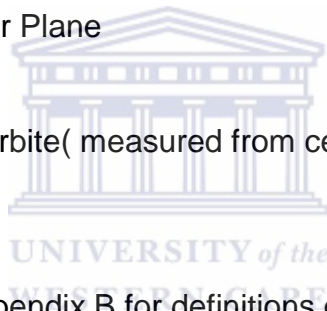


8.1 APPENDIX A

The variables were measured, recorded and compared in the study were as follows:

LANDMARKS:

- Horizontal and vertical Planes (see Appendix C)
- U6 ↓ to Maxillary Plane
- U6 → to PTV
- L6 ↑ to Mandibular Plane(GoGn)
- L6 → to PTV
- U1 to Maxillary plane
- U1 to NA
- L1 to Mandibular Plane
- L1 to NB
- Overjet and overbite(measured from cephalometric radiograph)



NOTE: Please see Appendix B for definitions of measurements used (acronyms and symbols).

8.2 APPENDIX B

- **Sella turcica (S):** the centre of the pituitary fossa of the sphenoid bone.
 - **Nasion (N):** the junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose.
1. **Orbitale (Or):** the lowest point on the average of the right and left borders of the bony orbit.
 2. **Porion (Po):** the upper border of the external auditory meatus (anatomic).
 3. **Point A (A):** also known as subspinale. The most posterior point on the curve of the maxilla between the anterior nasal spine and supradentale.
 4. **Point B (B):** also known as supramentale. The point most posterior to a line from infradentale to pogonion on the anterior surface of the symphyseal outline of the mandible: it should lie within the apical third of the incisor roots
 5. **Anterior nasal spine (ANS):** the tip of the median, sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
 6. **Posterior nasal spine (PNS):** the most posterior point at the sagittal plane on the bony hard palate.
 7. **Pterygo-maxillary fissure (PTM):** The contour of the pterygo-maxillary fissure formed anteriorly by the retromolar tuberosity of the maxilla and posteriorly by the anterior curve of the pterygoid process of the sphenoid bone.
 8. **Gonion (Go):** A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
 9. **Gnathion (Gn):** A point located by taking the midpoint between the anterior (pogonion) and inferior (menton) points of the bony chin.

- 10.SN** - Sella to Nasion
- 11.Frankfort Horizontal** – Porion to Orbitale
- 12.Palatal / Maxillary** – ANS to PNS
- 13.Occlusal Plane** – mesial cusp tip of upper first molar to the line bisecting the incisors
- 14.Mandibular** – Go to Gn
- 15.SNA** - Sella to Nasion to A point
- 16.SNB** - Sella to Nasion to B point
- 17.ANB** - A point to Nasion to B point
- 18.U6 ↓** - Upper 1st molar (vertical movement)
- 19.U6 →** - Upper 1st molar (horizontal movement)
- 20.L6 ↑** - Lower 1st molar (vertical movement)
- 21.L6 →** - Lower 1st molar (horizontal movement)
- 22.U1** - Upper central incisor
- 23.L1** - Lower central incisor
- 24.OJ** - Overjet
- 25.OB** - Overbite
- 26.PTV** -Vertical line parallel to the line posteriorly to the Pterygo-Maxillary (Ptm) fissure
- 27.deg** - Degrees
- 28.mm** - Millimeters

8.3 APPENDIX C

The list of abbreviated variables:

1. rx_ time- Treatment time
2. Diff 1- Upper first molar vertical movement
3. Diff 2 - Upper first molar horizontal movement
4. Diff 3 - Lower first molar vertical movement
5. Diff 4 - Lower first molar horizontal movement
6. Diff 5 - Upper central incisor vertical movement
7. Diff 6 - Upper central incisor horizontal movement
8. Diff 7 - Lower central incisor vertical movement
9. Diff 8 - Lower central incisor horizontal movement
10. Diff 9 - Overbite
11. Diff 10- Overjet
12. Diff 11- ANB
13. T1 - Total distance moved by the upper first molar
14. T2 - Total distance moved by the lower first molar
15. T3 - Total distance moved by the upper central incisor
16. T4 - Total distance moved by the lower central incisor



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9. REFERENCES

Adams CD, Meikle MC, Norwick KW and Turpin DL. 1972. Dento-facial remodeling produced by inter-maxillary forces in *Macaca mulatta*. Arch Oral Biol. 17:1519–1535.

Andrews LF. 1972. The six keys to normal occlusion. Am J Orthod. 61:297-309.

Angle EH. 1900. Malocclusion and the Teeth, 6th ed. SS White Dental Co. Philadelphia.

Angle EH. 1907. Treatment of Malocclusion of Teeth, 7th Ed. SS White. Philadelphia.

Angle EH. 1928. The latest and best in orthodontic mechanism. Dent Cosmos. 70:1143-58.



Barton JJ. 1971. A cephalometric comparison of cases treated with Edgewise and Begg techniques. Angle Orthod. 43(1):119-126.

Basciftci FA, Uysal T and Buyukerkmen A. 2003. Determination of Holdaway soft tissue norms in Anatolian Turkish adults. Am J Orthod Dentofacial Orthop. 123:395-400.

Beck BW and Harris EF. 1994. Apical root resorption in orthodontically treated subjects: Analysis of edgewise and light wire mechanics. Am J Orthod Dentofac Orthop. 105:350-61.

Begg PR. 1954. Stone age man dentition with reference to anatomically correct occlusion, the etiology of malocclusion, and a technique for its treatment. *Am J Orthod.* 40:298-312,373-383,462-475,517-531.

Begg PR and Kesling PC. 1977. *Begg Orthodontic theory and technique*, 3rd Ed. W.B Saunders Co.

Bennet JC and McLaughlin RP. 1998. *Orthodontic Management of the Dentition with the preadjusted appliance*. ISIS Medical Media.

Bishara SE, Justus R and Graber TM. 1998. Proceedings of the workshop discussions on early treatment: Held by the college of Diplomates of the American Board of Orthodontics in Quebec City, Canada on July 13-17, 1997. *Am J Orthod Dentofacial Orthop.* 113(1): 5-10.

Bishara SE. 2001. *Textbook of Orthodontics*. W.B. Saunders Co. Philadelphia.

Bishara SE. 2006. Class II Malocclusions: Diagnostic and Clinical Considerations With and Without Treatment. *Semin Orthod.* 12:11-24.

Brandt S and Safirstein GR. 1975. Different extractions for different malocclusions. *Am J Orthod.* 68(1): 15-41.

Broadbent BH. 1931. New X-ray technique and its application to Orthodontia. *Angle Orthod.* 1:45-66.

Broadbent BH. 1937. Bolton standards and technique in Orthodontic practice. *Angle Orthod.* 7:209.

Broadbent BH. 1942. Ontogenetic Development of Occlusion. Angle Orthod. 11:223.

Brodie AG. 1941. On the growth pattern of the human head. Am J Anat. 1:633-647.

Burstone CJ. 1977. Deep overbite correction by intrusion. Am J Orthod. 72(1):1-22.

Case CS. 1964. The question of extraction in Orthodontia. Am J Orthod. 50:658-691.

Cortella S. Shofer FS. Ghafari. 1997. Transverse development of the jaws norms for the postero-anterior cephalometric analysis. Am J Orthod Dentofacial Orthop. 112: 519-522.



DeShields RW. 1969. A study of root resorption in treated Class II division 1 malocclusions. Angle Orthod. 39:231-245.

Downs WB. 1948. Variations in facial relationships: Their significance in treatment and prognosis. Am J Orthod. 34: 812- 840.

Edwards JG. 1983. Orthopedic effects with "conventional" fixed orthodontic appliances: A preliminary report. Am J Orthod Dentofacial Orthop. 84:275-291.

Ellen EK, Schneider BJ, Selike T. 1998. A comparative study of anchorage in bioprogressive versus standard edgewise treatment in Class II

correction with intermaxillary elastic force. *Am J Orthod Dentofac Orthop.* 11:430-436.

Evanko AM, Freeman K and Cisneros GJ. 1997. Mesh diagram analysis developing a norm for Puerto Rican Americans. *Angle Orthod.* 67: 381-388.

Forster TD. 1990. *A Textbook of Orthodontics*, 3rd Ed. Blackwell Scientific Publications. 11: 209-230.

Galicia-Ramos GA, Killiany DM, Kesling PC. 2001. A comparison of standard edgewise, preadjusted edgewise, and Tip-Edge in Class II extraction treatment. *J clin orthod.* 35(3):145-153.

Gianelly AA, Arena SA, Bernstein L. 1984. A comparison of Class II treatment changes noted with the light wire, edgewise, and Frankel appliances. *Am J Orthod.* 86:269–276.

Goldson L and Henrikson CO. 1975. Root resorption during Begg treatment: a longitudinal roentgenologic study. *Am J Orthod.* 68:55-66.

Graber TM, Rakosi T, Petrovic AG. 1997. *Dentofacial Orthopedics with functional appliances*, 2nd ed. St. Louis: Mosby Inc.

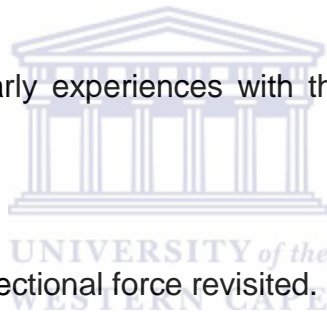
Graber TM, Vanarsdall RL Jr. 2005. *Orthodontics Current Principles and Techniques*, 3rd ed. St Louis, MO: Mosby.

Graber TM, Vanarsdall RL and Vig KWL. 2005. Treatment of patients in the mixed dentition: Current principles and techniques, 4th ed. St Louis. Elsevier Mosby.

Hanes RA. 1959. Bony profile changes resulting from cervical traction compared with those resulting from intermaxillary elastics. Am J Orthod. 45:353–364.

Harris EF and Butler ML. 1992. Patterns of incisor root resorption before and after orthodontic correction in cases with anterior open bites. Am J Orthod Dentofac Orthop. 1: 112-9.

Harrison JE. 1998. Early experiences with the Tip-Edge Appliance. Br J Orthod. 25:1-9.



Hickham JH. 1986. Directional force revisited. J Clin Orthod. 20:626-637.

Huertas D and Ghafari J. 2001. New postero-anterior cephalometric norms a comparison with craniofacial measures of children treated with palatal expansion. Angle Orthod. 71: 285-292.

Hwang HS, Kim VVS and McNamara JA. 2002. Ethnic differences in the soft tissue profile of Korean and European-American adults with normal occlusion and well-balanced faces. Angle Orthod. 72: 72-80.

Jarabak JR and Fizzell JA. 1972. Technique and Treatment with Lightwire Edgewise Appliance. St Louis, Mo: C.V Mosby.

Kaley J and Phillips C. 1991. Factors related to root resorption in edgewise practice. *Angle Orthod.* 2:125-132.

Keeling SD, Wheeler TT, King GJ, Garvan CW, Cohen DA, Cabassa S, McGorray SP and Taylor MG. 1998. Anteroposterior skeletal and dental changes after early Class II treatment with bionators and headgear. *Am J Orthod Dentofacial Orthop.* 113:40-50.

Kesling PC. 1985. Begg Theory and Technique: past, present and future. In *New Vistas Orthodontics* by Johnson L.E. pp 209-238.

Kesling PC. 1988. Expanding the horizon of the edgewise arch wire slot. *Am J Orthod Dentofac Orthop.* 96:16-25.

Kesling PC. 1989(a). Dynamics of the Tip-Edge bracket. *Am J Orthod Dentofac Orthop* 96:16-25.

Kesling CK. 1992. The Tip-Edge concept: Eliminating unnecessary anchorage strain. *J Clin Orthod.* 25(3):165-178.

Kesling PC. 2003. *Tip-Edge Guide to the differential straight-arch technique*, 5th ed. Indiana.

Kesling PC. 2006. *Tip-Edge Guide to the differential straight-arch technique*, 6th ed. Indiana.

Ketcham AH. 1927. A preliminary report of an investigation of apical root resorption of permanent teeth. *J Orthod.* 13:97127.

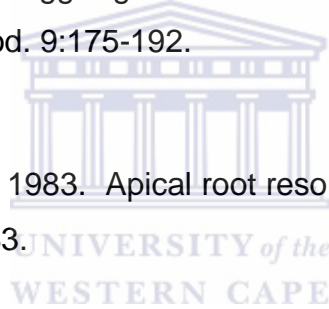
Ketcham AH. 1929. A progress report of an investigation of apical root resorption of vital permanent teeth. *Int. J. Orthod.* 15:310-328.

Krogman WH. Sassouni V. 1957. *A Syllabus in Roentgenographic Cephalometry*. Philadelphia: Philadelphia Center for Child Growth;

Langlade M. 1978. Upper anterior occlusal plane control. *J Clin Orthod.* 12:656-659.

Levin RI. 1987. The Begg light wire technique and dento-facial development. *Eur J Orthod.* 9:175-192.

Linge BO and Linge L. 1983. Apical root resorption in upper anterior teeth. *Eur J Orthod.* 5:173-183.



McFadden WE, Engstrom C, Engstrom H and Anholm JM. 1989. A study of the relationship between incisor intrusion and root shortening. *Am J Orthod Dentofac Orthop.* 96:390-396.

McLaughlin RP, Bennett JC and Trevisi H. 1997. A clinical review of the MBT orthodontic treatment program. *Orthodontic Perspectives.* 5(2):3-8.

McLaughlin RP and Bennett JC. 1989. The transition from standard edgewise to preadjusted appliance systems. *J Clin Orthod.* 23:142-53.

McNamara JA Jr. 1981. Components of Class II malocclusion in children 8-10 years of age. *Angle Orthod.* 51:177-202.

McNamara JA Jr. 1981. Components of class II malocclusion in children 8-10 years of age. *Angle Ortho.* 65:49-62.

McNeil RW. 1974. *The edgewise appliance in Orthodontics in Daily Practice.* Salzman JA. JB Lippincott Company. Philadelphia.

Miyajima K and Lizuka T. 1996. Treatment mechanics in Class III open bite malocclusion with Tip-Edge technique. *Am J Orthod Dentofac Orthop.* 110:1-7.

Miyajima K. McNamara JA, Kimura T, Murata S and Lizuka T. 1996. Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces, *Am J Orthod Dentofac Orthop.* 110: 431-438.



Mollenhauer B. 1987. Towards paradigmless orthodontics. *Am J Orthod Dentofac Orthop.* 92:437-44.

Nelson B, Hansen K and Hagg U. 2000. Class II correction in patients treated with class II elastics and with fixed functional appliances: a comparative study. *Am J Orthod Dentofac Orthop.* 118:142–149.

Odenrick L and Brattstrom V. 1983. The effect of nailbiting on root resorption during orthodontic treatment. *Eur J Orthod.* 5:185-8.

Odenrick L and Brattstrom V. 1985. Nailbiting: frequency and association with root resorption during orthodontic treatment. *Br J Orthod.* 12:78-81.

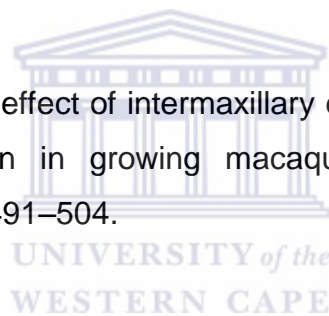
Owen AH. 1984. III Diagnostic Block cephalometrics. *J Clin Orthod.* 18(6): 400-422

Pacini AJ. 1922. Roentgen ray anthropometry of the skull. *J Radial.* 3:230-231, 322-331, 418-426.

Parkhouse RC. 1998. Rectangular wire and third-order torque: A new perspective. *Am J Orthod Dentofac Orthop.* 113: 421-30.

Parkhouse RC. 2003. *Tip-Edge Orthodontics.* Elsevier Mosby. Philadelphia.

Payne GS. 1971. The effect of intermaxillary elastic force on the temporomandibular articulation in growing macaque monkey. *Am J Orthod Dentofac Orthop.* 60: 491–504.



Philippe J. 1995. Mechanical analysis of Class II elastics. *J Clin Orthod.* 29:367–372.

Pollock HC. 1964. The extraction debate of 1911 by Case, Dewey, and Cryer. *Am J Orthod.* 50(9): 656- 659.

Proffit WR. 2007. *Contemporary Orthodontics*, 4th ed. Mosby.

Reddy P, Kharbanda OP, Duggal R and Parkash H. 2000. Skeletal and dental changes with none therapy in patients with Class II division 1 malocclusion. *Am J Orthod Dentofac Orthop.* 118:641-648.

Reitan K. 1960. Tissue behavior during orthodontic tooth movement. *Am J Orthod.* 46:881-900.

Reitan K. 1974. Initial tissue behavior during apical root resorption. *Angle Orthod.* 44:68-82.

Remmer KR, Mamandras AH, Hunter WS and Way DC. 1985. Cephalometric changes associated with treatment using the activator, the Frankel appliance and the fixed appliance. *Am J Orthod.* 88:363–372.

Ricketts RM, Bench RW, Gugino CF, Hilgers JJ and Schulof RJ. 1980. *Bioprogressive Therapy Book*, 2nd ed. Denver, CO: Rocky Mountain Orthodontics.

Rocke RT. 1994. Employing Tip-Edge brackets on canines to simplify straight-wire mechanics. *Am J Orthod Dentofac Orthop.* 106:341-50.

Roth RH. 1987. The straight wire appliance: 17 years later. *J Clin Orthod.* 11:632-634.

Roth RH. 2000. Treatment concepts using the fully preadjusted three-dimensional appliance. Chapter 14 in Graber TM and Vanarsdall RL. *Orthodontics: Current Principles and Techniques*, 3rd ed. Mosby, Inc.

Sassouni V and Forrest EJ. 1971. *Orthodontics in Dental Practice*. St. Louis, the C.V. Mosby Company.

Sims MR. 1964. The Begg philosophy and fundamental principles. Am J Orthod. 50: 15-24.

Shudy FF. 1965. The rotation of the mandible resulting from growth: its implications in orthodontic treatment. Angle Orthod. 1: 36-50.

Shudy FF. 1992. JCO interviews on the vertical dimensions. J Clin Orthod. 26:463-473.

Stockli P and Teuscher UM. 1982. The activator-headgear combination in skeletal class II treatment. Mershon memorial lecture, presented at the annual meeting of the American Association of Orthodontics, Atlanta. Cited in Graber TM, Rakosi T and Petrovic AG. 1997. Dentofacial Orthopedics with Functional Appliances, 2nd ed. St. Louis, Mosby-Year Book Inc.

Stuteville O. 1938. Injuries caused by orthodontic forces and the ultimate results of these injuries. Am J Orthod Oral Surg. 24:103-19.

Swerenga D, Oesterle LJ and Messersmith ML. 1994. Cephalometric values for adult Mexican-Americans. Am J Orthod Dentofacial Orthop. 106:146-155.

Ten Hoeve A and Mulie RM. 1976. The effect of antero-postero incisor repositioning on the palatal cortex as studied with laminagraphy. J Clin Orthod. 10:804-22.

Thompson WJ. 1988. Combination anchorage technique: An update of current mechanics. Am J Orthod Dentofac Orthop. 93:363-79.

Travess H, Roberts-Harry D and Sandy J. 2004. Orthodontics, Part 8: Extractions in orthodontics. Br Dent J. 196(4): 195- 203

Tulley WJ. 1959. The role of Extractions in Orthodontic Treatment. Br Dent J. 107(8): 199- 209.

Tulloch JFC. 1978. Treatment Following Loss of Second Premolars. Br J Orthod. 5: 29-34.

Tulloch JFC, Phillips C and Proffit WR. 1998. Benefit of early class II treatment. Am J Orthod Dentofac Orthop. 113(1):62-72.

Tulloch JFC, Proffit WR and Phillips C. 2004. Outcomes in a 2-phase randomized clinical trial of early Class II treatment. Am J Orthod Dentofac Orthop. 125:657-667.

Uzel A, Uzel I and Toroglu S. 2007. Two different applications of class II elastics with nonextraction segmental techniques. Angle Orthod. 77(4):694-700.

Vaden JL, Dale JG and Klontz HA. The Tweed-Merrifield Edgewise Appliance: Philosophy, Diagnosis and Treatment in Graber TM and Vanarsdall RL, (eds): Orthodontics. Current Principles and Techniques, 3rd ed. The C.V. Mosby Company, 2000.

Van der Linden FPGM. 1989. Facial growth and orthopedics. Quintessence Publishing Co.

Van Loon JA. A new method in demo-facial orthopedia, parts 1 and 2
Dental Cosmos 1915, 7: 1093-1101, 1229-1235.

Von der Ahe G. 1973. Post-retention status of maxillary incisors with root-
end resorption. Angle Orthod. 43:247-255.

Wainwright W. 1973. Faciolingual tooth movement: its influence on the root
and cortical plate. Am J Orthod. 64:278-302.

Wylie WL. 1947. Assessment of anteroposterior dysplasia. Angle Orthod.
17:97

Zachrisson BU. 1976. Cause and prevention of injuries to teeth and
supporting structures during orthodontic treatment. Am. J Orthod. 69:285-
300.

