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CEPHALOMETRIC EVALUATION OF ANTERIOR OPEN BITE
TREATMENT WITH NİTİ WIRES AND ANTERIOR ELASTICS IN
YOUNG ADOLESCENTS

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CEPHALOMETRIC EVALUATION OF ANTERIOR OPEN BITE TREATMENT WITH Ni Ti WIRES AND ANTERIOR ELASTICS IN YOUNG ADOLESCENTS

2. Summary

2.1. English Summary

Our aim in this study is cephalometric evaluation of the treatment after the closure of anterior open bite in adolescents.

The study involved 10 patients (8 females and 2 males); average age was 13.5 year. They were selected from the clinical intake of the dental faculty of Marmara University. All patients exhibited Class I or mild Class II relationship, with anterior open bite more than 1 mm.

In this study we used upper accentuated and lower reverse curved Ni-Ti arch wires and anterior elastics which is a modification for Kim's technique (57). This modality of treatment was stopped when sufficient incisal overlap was achieved.

Lateral cephalometric films were obtained before and immediately after the closure of the open bite.

The cephalometric analysis showed that most dental parameters showed significant changes. The significant changes achieved were as follows: the lower incisors extruded with an average of 3.00 mm, and uprighted by 4.56°. The upper incisors extruded 2.00 mm and uprighted by 4.89°.

Both upper and lower first molars uprighted significantly (12.44°,10.33° respectively) while extruded insignificantly, 0.33mm for each.

There were no significant skeletal changes except for a slight increase in N-Me and ANS-Me (1.56mm, 1.78mm respectively).

The overbite was increased by 3.89 mm, due to the extrusion of the upper and lower incisors, while the overjet was reduced by 0.89 mm which is due to uprighting of both upper and lower incisors.

As a conclusion this technique was effective in the treatment of open bite in young adolescents. Further studies are suggested to investigate the long term stability of our results.

2.2. Türkçe Özet

Bu çalışmadaki amacımız yetişkinlerde ön açık kapanışın kapatılmasından sonra tedavinin sefalometrik olarak değerlendirilmesidir.

Bu çalışmada ortalama yaşları 13.5 olan 10 hasta yer almaktadır (8 kız,2 erkek).

Hastalar Marmara Üniversitesi Dişhekimliği Fakültesinin kliniğinden seçilmişlerdir.

Bütün hastalar 1 mm den fazla ön açık kapanışa sahip olup Sınıf I veya hafif Sınıf II kapanış göstermektedirler.

Bu çalışmada Kim tekniğinin (57) bir modifikasyonu olarak üst çenede arttırılmış, alt çenede ters Spee eğrisi içeren Ni Ti arklar ve anterior elastikler kullanılmıştır.

Tedaviden önce ve ön açık kapanışın düzeltilmesinden hemen sonra lateral sefalometrik filmler çekilmiştir.

Sefalometrik analizde bir çok dental parametrenin belirgin değişiklikler gösterdiği belirlenmiştir. Bu değişiklikler aşağıdaki gibidir: Alt kesicilerde ortalama 3 mm ekstrüzyon, 4.56° dikleşme, üst kesicilerde 2.00 mm ekstrüzyon 4.89° dikleşme görülmüştür.

Üst ve alt birinci molarlar belirgin biçimde dikleşmiştir (sırasıyla 12.44°, 10.33°). Aynı zamanda her biri istatistiksel olarak anlamlı olmamakla birlikte 0.33 mm uzamıştır. N-Me ve ANS-Me daki çok az artış dışında (sırasıyla 1.56mm, 1.78mm) bir iskelesel değişiklik görülmemiştir.

Overbite alt ve üst kesicilerin uzaması nedeniyle 3.89 mm artmış, overjet ise alt ve üst kesicilerin dikleşmesi nedeniyle 0.89 mm azalmıştır.

Sonuç olarak bu teknik genç yetişkinlerin tedavisinde etkilidir. İleriki çalışmalarda sonuçlarımızın stabilitesini uzun dönemde araştırılması önerilmektedir.

3. ABBREVIATIONS

1. SD : Standard deviation
2. X : Statistical mean
3. D : Difference
4. P : Probability
5. Sig : Significance
6. mm : Millimeter
7. cm : Centimeter
8. " : Inch
9. hr : Hour
- 10.yr : Year
- 11.° : Degree
- 12.% : Percentage
- 13.< : Less than
- 14.Fig. : Figure
- 15.gm : Gram
- 16.TMJ : Tempromandibular joint
- 17.et al : And others

4. INTRODUCTION

The treatment of patients with anterior open bite has proved to be one of the most challenging aspects of orthodontics. Among the etiologic factors in an open bite development are: 1) a morphogenetic abnormality resulting in a disturbance of skeletal development, 2) an expression of muscle growth and muscle function, and 3) a mal-placement or displacement of anterior teeth.

Successful orthodontic therapy necessitates a careful appraisal of the etiologic factors, an accurate determination of where the skeletal and dental abnormality exists, an accurate appraisal of the individual growth pattern, and, finally, the development of an individualized treatment plan to address these factors.

Two types of open bite were described, one skeletal and one dental.

Dental open bites are caused by obstructed eruption of anterior teeth but known to be self correcting, and responding well to myofunctional and mechanotherapy if the habit or cause is eliminated at an early age.

The skeletal open bite is harder to treat and can be characterized by a problem of excessive vertical growth of the maxilla, often more posteriorly than anteriorly, coupled with downward backward rotation of the mandible and excessive eruption of the maxillary and mandibular teeth.

Skeletal open bite treatment is more difficult and challenging, several appliances were developed in order to treat this condition. Functional appliances were developed to treat this condition; techniques to extrude anterior teeth and intrude posterior teeth were also tried. However surgery could be acknowledged as the main and most efficient treatment option in such cases. For the treatment

of borderline cases, and those individuals who are reluctant to undergo surgery, the search for effective treatment modalities continues.

The use of upper accentuated and lower reverse curve Ni Ti arch wires along with anterior elastics is one of the ways to correct an open bite.

A previous study conducted on adults by Kucukkeles et al (112) has shown that the correction of open bite with these mechanics involved extrusion of upper and lower incisors rather than molar intrusion, which is the more desirable one of the two effects. These results would bring up the question whether it would be possible to achieve molar intrusion with these mechanics at a younger age group.

Our aim in this study was to evaluate the clinical effects of upper accentuated and lower reverse curve NiTi arches in anterior open bite treatment in young adolescents, and find out if it was actually possible to achieve molar intrusion.

4.1. LITERATURE REVIEW

4.1.1 Definition and incidence

In the literature we can find many definitions for the open bite. Swinehart (111) defined open bite as: “ abnormal condition in which group of teeth do not make occlusal contact because of lack of requisite vertical extension”. Subtelny and Sakuda (107) considered any case as an open bite case only when “a degree of openness is available with lack of contact of the anterior teeth”.

Worms et al (119) defined as “the absence of contact between maxillary and mandibular incisors at centric relation”.

Mizrahi (71) defined it as “that the condition where the upper incisor crowns fail to overlap the incisal third of the lower incisor crowns when the mandible is brought into full occlusion”.

Kim (57) defined the anterior open bite as the case where “ the teeth in the anterior portion of the maxilla and mandible are vertically apart and lack of the overlapping necessary for the incisive function when the mandible is in closed position” Stated in another way, the occlusal planes of the maxillary and mandibular dentitions fail to overlap anteriorly.

Katsaros and Berg (52) defined the open bite as “no occlusal contacts of the incisors, neither in the habitual occlusion , nor following forward sliding of the lower dental cast, having always at least two occlusal contacts on the molars bilaterally in the sagittal plane.

In a very recent definition Shapiro (101) defined open bite as the lack of overlap of the anterior teeth in centric occlusion. Overlap pertains to the incisal edges as viewed from the anterior; the mandibular incisors do not contact any

opposing structures, such as the maxillary incisors or the palate. Contact occurs when the anterior and posterior teeth touch opposing structures in centric occlusion.

Brunnele et al (10) reported the incidence of certain occlusal traits in non institutionalized people in the United States. Three racial groups (whites, blacks and Mexicans) were examined from age 8 years through 50 years. They found less than 5% of the sample had an anterior open bite when the posterior teeth are in occlusion. Average open bite for all persons having this condition was 1.1 mm. and average open bite was similar in males and females. In all persons with open bite, the younger ages 8 to 11 had greater average open bite (1.9 mm) than the 12-17 age group (1.0 mm) and the 18-50 age group (1.0 mm). This decrease may be related to growth and environmental influence such as oral habits. Black had significantly greater average open bite (1.6mm) than white (0.8 mm) and Mexican Americans (1.1 mm).

While Korkhaus (60) found the incidence of anterior open bite to be 4.2% in 6 year old children, the percentage dropped to 2.5% in 14 year old children. The decrease in the anterior open bite was attributed to the self-correction of the open bite as the habits causing it are gradually disappearing from the young population.

Kelly et al (53) gathered information from 8000 children 6 to 11 years of age. They found open bite "more than 2 mm" in 1.4% of white children while this percentage was 9.6% in black children at the same age group.

Tulley (114) studied 1500 eleven year old children. and found that less than 1% had open bite.

Worms et al (119) studied 1408 children and young adults between 7 and 21 years of age. They noticed also that the incidence of open bite in girls was more than boys in older ages, and that open bite in Class II cases was more than Class I cases. Another finding was that open bite decreased with age, and they demonstrated this by showing that 17% of boys in 7-9 years showed simple or compound open bites while at the age of 19-21 the percentage went down to 4%. As for girls the percentage of open bite stayed 11% and did not change during

that period. Again they attributed this decrease in the prevalence of open bite to positive skeletal growth, maturation of swallowing reflex, and transition from mixed dentition to permanent dentition.

4.1.2. Classification and characteristics

We can divide open bite into two types: skeletal and dental.

According to Cangialosi (12) dental open bite demonstrate undereruption caused by an object that prevents incisor eruption. Once the digit is removed, a dental open bite tends to self correct. Cangialosi reported that skeletal open bites show more molar and incisor eruption than do dental open bites.

According to Proffit (81) dental open bites are caused by obstructed eruption of anterior teeth but known to be self correcting, and responding well to myofunctional and mechanotherapy if the habit or cause is eliminated at an early age.

The skeletal open bite is harder to treat and can be characterized by a problem of excessive vertical growth of the maxilla, often more posteriorly than anteriorly, coupled with downward backward rotation of the mandible and excessive eruption of the maxillary and mandibular teeth, if the size of mandible is normal, the rotation produces a relative mandibular deficiency in the anterior posterior plane of space, patient is described as Class I rotated to Class II. If the mandible is large, the condition can become a Class III rotated into Class I, but if it is small "Class II rotated to very severe Class II can be the description".

They reported (12) that long face "skeletal open bite" patients may or may not have a dental open bite. Only if the posterior teeth erupt more than the anteriors will the patient have anterior open bite malocclusion.

Cangialosi et al (12) tried to differentiate skeletal open bite and habitual dentoalveolar open bite. They stated that while there is considerable anterior opening in both, the great variation in skeletal morphology is apparent. In addition to the skeletal pattern, the amount of eruption of the teeth is also useful in distinguishing between the two. In skeletal open bite the anterior teeth are

likely to be normally erupted or even overerupted, whereas in habitual open bite they are undererupted because of the presence of some object (tongue, thumb, pencil, etc.).

In the same study (12) they concluded the following characteristics of open bite compared to norm.

1. Posterior face height is shorter and overall anterior face height is greater in open-bite subjects.

2. Lower face height is greater in relation to upper anterior face height in persons with open bite.

3. The mandibular plane angle and the gonial angle are larger in persons with open bite.

4. The PP-GoGn angle is greater in persons with open bite, and this is due mostly to downward tipping of the mandibular plane in this sample.

5. Ratios and angles measured remained relatively constant in both mixed- and permanent-dentition groups, indicating that only size (but not facial proportion) changes with age.

6. Measurements made on the group designated as having skeletal open bites were significantly different from those of the subjects with dentoalveolar open-bites and from the open bite sample as a whole, except for the Sn-PP angle.

Nahoum, in a study of 52 open bite cases stated that it was not possible to differentiate between skeletal and dental open bites, as both showed signs of the other. He considered facial typing as useful for generalizations but misleading for individuals (73).

Another category that can be added here is what was called as an anterior open bite tendency. These cases would develop into open bite with treatment or abnormal growth. Several attempts also have been made to identify cases that could be considered as anterior open bite tendency cases. A review of literature showed that there was no accepted method to determine the presence of open bite tendency. Studies have been done to identify any signs that could be linked

or associated with such a condition but researchers were not able to identify any (18).

Many authors agree that it is essential to distinguish between dental and skeletal open bites (6). However, difficulty arises in the numerous intermediate cases where the distinction between the two is not clear (39). Several articles have been published on characteristics associated with skeletal open bites. These include increased lower face height (6,68,74), short posterior face height (6,45,68,74), marked antegonial notching (6,38), increased maxillary molar dentoalveolar height (99), and increased gonial and mandibular plane angles (20, 39, 57).

In the literature open bite has been associated with many features. It should be mentioned though that the presence of these feature in a case does not mean necessarily that it is an open bite case and vice versa. So even in open bite cases it is not necessary to find all these features. It is just that these features are present more in open bite cases than in ordinary population.

Lopez et al (68) tried to categorize and describe open bite patients. They found the following list of open bite characteristics:

1. Excessive gonial, mandibular, and occlusal plane angles
2. Decreased palatal plane angle
3. Small mandibular body and ramus
4. Increased lower anterior facial height
5. Decreased upper anterior facial height
6. Shorter nasion-basion distance
7. Retrusive mandible
8. Increased anterior and decreased posterior facial height
9. Class II tendency
10. Divergent cephalometric planes
11. Steep anterior cranial base.

Kim et al (57) stated that mandibular plane and the gonial angles are usually quite obtuse in open bite cases, with the appearance of a longer lower

face height. Neither the obtuseness of the mandibular configuration nor the longer lower face height alone however provide definitive diagnostic criteria.

Bilin (7) et al mentioned that a high and narrow palatal vault was characterized as one of the distinguishing features of anterior open bite. And in another model study Isaacson et al (45) drew attention to the transverse dimensional difference among different vertical facial patterns. A narrower maxillary intermolar width was found in the high mandibular angle cases compared with average angle cases, and a wider dimension was found for low angle cases than for average ones. In addition to the group mean comparison, even more interesting to clinicians is the amount of transverse discrepancy between upper and lower jaws of the anterior open bite and the nature of this discrepancy.

The so-called high vault palate may be referred to synonymously as the overgrowth of posterior maxillary dentoalveolar height, which is a commonly cited causal factor in anterior open bite cases (20, 96).

However, Nahoum et al (74) did not find any significant difference in the posterior maxillary dentoalveolar heights between their open bite and normal samples.

Schudel (98) in his comparison study of vertical maxillary excess cases, saw no evidence of longer palatal heights for open bite than non-open bite cases. No consensus exists as to the correlations between posterior vertical maxillary excess and anterior open bite in the lateral cephalometric studies.

According to Jeryl (50), hyperdivergent patients display these characteristics: short posterior face height, long lower anterior face height, larger mandibular plane and gonial angles, and downward tipping of the posterior maxilla. Patients usually have increased dentoalveolar heights, and they might also have maxillary constriction and posterior crossbites, a retruded mandible and an anterior open bite in combination with a tongue thrust habit.

4.1.3. Etiology

Reymond et al (84), reported that many factors have been suggested as potential causes of open bite and they could be divided into three main categories:

1. Vertical skeletal growth discrepancies, defined as excessive vertical eruption of the maxillary molars and alveolus that subsequently hinges the mandible down and back. In addition, factors such as underdevelopment of the middle cranial fossa height producing an elevation of the glenoid fossa, and inadequate alveolar growth in the anterior portion of the maxilla have been suggested as potential causative factors.

2. Abnormal muscular and soft tissue development, particularly when associated with airway problems, may lead to increased anterior facial height and open bite. In the past, researchers have also credited the postural and swallowing positions of the tongue with causing anterior open bites. A more widely accepted hypothesis is that tongue thrust and orofacial musculature imbalance are secondary factors possibly enhancing or maintaining the underlying skeletal or dental dysplasia, rather than being primary causative factors.

3. Many researchers have related and documented thumb sucking and other habits to the formation and maintenance of anterior open bites, and have suggested a wide range of treatment techniques directed at eliminating the obvious causative factors.

The etiology of anterior open bite is multi-factorial. No single factor can account for most open bites; a prolonged thumb-sucking habit might be a likely cause of open bite, but thumb-sucking can also coexist with deep overbite or

overjet. Other aspects of facial form and function will combine to determine whether the ultimate result will be an open bite or deep overbite.

Naturally, thumb-sucking per se also varies greatly among children. The posture of thumb positioning, the intensity, and the frequency of sucking, all have an effect. However, the skeletal pattern must also embody the basic vulnerability that differentiates open bite from deep overbite.

To pursue these differences, the Overbite Depth Indicator (ODI) was introduced in a study of 119 normal children and 500 children with malocclusions ranging from deep overbite to open bite (56). That study demonstrated a positive relationship between the ODI and overbite. Incidence of open bite is greatest with ODI values below the mean (74.5°), and the incidence of deep overbite is greatest with higher ODI values. Accordingly, one aspect of the nature of open bite and the skeletal pattern can be evaluated with the aid of the ODI analysis (56, 84).

Severe nail-biting can also produce detrimental effects, depending on the relationship between the intensity of the habit and the degree of skeletal deviation from the norm.

Of all the possible etiologic factors that have been studied, perhaps the greatest importance focuses on nasopharyngeal airway obstruction. Studies on human subjects have documented correlations between open bite malocclusion and the mode of natural breathing (nasal breathing or mouth breathing) (61, 65, 108, 109). The consensus of opinion is clear that nasopharyngeal airway obstruction induces mouth breathing.

Mouth breathing, in turn, requires a lowered tongue position, especially a lower level of the dorsum. The lower tongue position creates a posterior crossbite and/or an anterior open bite. Experiments on monkeys conducted to test this theory have demonstrated the resultant open bite (36, 37).

A deviant oral physiologic behavior such as this is also known to produce a long-face syndrome or adenoid faces (33, 36, 37, 42, 61, 65, 66, 82, 90, 108).

Subsequent to Linder-Aronson's extensive study on this subject (66), they reported that out of 81 children who had adenoidectomy because of

enlargement, only 25% had adenoid faces. Why, then, were the remaining 75% not affected by the enlargement of the adenoid tissue? For that matter, aren't there people with long faces who have no history of nasopharyngeal airway obstruction?

It is also reported that most nasopharyngeal airway obstructions are derived from allergic reactions that develop during infancy, often from dairy products (92).

Early detection of such symptoms is therefore recommended, so that a treatment can be provided in time to prevent these effects. If hypertrophied adenoid tissue is causing obstruction, a reasonable remedy is to remove the enlarged lymphatic tissue (65, 66, 82, 90, 92, 108).

In 1931, Hellman (40) conducted a study on 43 patients, both treated and untreated, who exhibited anterior open bite. Of those cases which were treated, he found that the percentage of successful treatments was equal to the number of spontaneous self-corrections in the untreated group. On the basis of these observations, he suggested that open bite is primarily due to skeletal growth deficiencies. However, Swinehart (111) and Straub (106) concluded that tongue thrust is the primary cause of open bite and that retraining the tongue and eliminating muscle dysfunction will correct the condition. On the other hand, Subtelny and Subtelny (110) have indicated, after reviewing the literature, that muscular activity during deglutition is principally dictated by form. That is, the tongue is thrust forward in order to affect the oral seal necessary for this act. Therefore, it becomes questionable as to whether tongue thrust causes open bite or whether the reverse is true.

Age and growth factors also play an important role in anterior open bite. In a study of 1408 children, Worms (119) found that there was a spontaneous correction of 80% of the anterior open bites as one proceeds from a 7 to 9 year age group to a 10 to 12 year age group. Other studies have shown that tongue thrust (24, 117) is the main mode of swallowing up to the age of 10 years. After that age, there is a marked decrease in this form of swallowing, which may account for the spontaneous correction in the study previously referred to.

In a review of the literature it has become obvious that most investigators believe that tongue thrust cannot be considered the primary etiologic factor in the majority of open-bite cases. Cephalometric appraisal of open-bite and normal patients has proved to be a useful tool in pointing out the morphologic differences in both and indicating the specific areas responsible for this condition.

In 1964 Schudy (99) stated that vertical dimension is the most important dimension to the clinical orthodontist and that vertical dysplasias are inseparably related to both open and closed bites. He also stated that retrognathic persons are likely to exhibit greater lower face height, whereas prognathic persons are more likely to exhibit a shorter lower face height. In computing the ratio of posterior to anterior face height, he measured posterior face height from articulare to the mandibular plane, tangent to the posterior border of the ramus at the gonial angle. Anterior face height was measured from nasion to menton. He found that the ratio was 62.91% in an average group, 57.23% in a retrognathic group, and 69.28% for a prognathic group.

Hapak (35) in a cephalometric appraisal of open bite, concluded that it occurs with a variety of skeletal patterns. The sample that he studied showed a Class II tendency and proved to be retrognathic on the Downs facial diagram. It also showed an average Frankfort-mandibular plane angle of 33.4° and a sella-nasion to GoGn angle that was 6.3° greater than normal.

Richardson (87, 88) found that there was a significantly greater lower face height and greater jaw and joint angles in open bite cases. He concluded that the cause of open bite from 7 to 10 years of age is delayed vertical growth of the upper face and increased lower face height, combined with a lack of vertical growth of the dentoalveolar structures. He believes that, with time, the growth of the upper face will correct itself but that vertical development of the dentoalveolar structures will never catch up. Therefore, it seems that anterior open bite may be attributed to both skeletal and dentoalveolar discrepancies.

Moss and Salentyn (72) studied the position of the inferior alveolar nerve. They took a large series of skulls at various dental ages and placed metallic implants in the three foramina (foramen ovale, mandibular foramen, and mental

foramen). They then took cephalometric radiographs and, using norma lateralis, described the following: They showed that the three foramina of the inferior alveolar nerve fall on a logarithmic curve and that in open-bite cases the foramen ovale is placed further down on the logarithmic spiral than for any other group studied. This is as a result of developmental abnormalities in the oral functioning space acting as a capsular matrix. They stated that this information might be significant and diagnostic of an impending open bite at an early age before it is manifested clinically.

Nahoum (73) found that the ratio of upper face height to lower face height was smaller for open bite subjects and that this ratio was constant at all ages. These measurements were made for both male and female patients, although there was a 10% increase in total face height in males, the ratios of upper to lower face height for the control group were not significantly different. In the open bite group, this ratio was extremely similar for both males and females; therefore, the data were pooled. Nahoum also found that the SN-to-palatal-plane (SN-PP) angle was smaller and the PP-GoGn angle was greater for open bite subjects, which may suggest a tipping upward of the palatal plane anteriorly. The Sn GoGn angle was greater in the open bite subjects, suggesting a greater overall anterior face height.

In a second study (74) it was concluded that persons with open bite have a greater lower anterior face height and generally a shorter posterior face height. They were also found to have a larger gonial angle. In this study, posterior face height was measured from sella to gonion.

Galleto et al (27) reported that among the etiologic factors in an open bite are (1) a morphogenetic abnormality resulting in a disturbance of skeletal development, (2) an expression of muscle growth and muscle function, and (3) a malplacement or displacement of anterior teeth.

Sarver et al (95) reported that like most orthodontic problems, the cause of open bite is often multifactorial. Etiologic factors most often cited in the literature include "open bite skeletal pattern," vertical maxillary excess, abnormalities in dental eruption, and tongue posture problems. As Isaacson (45) and Richardson

(88) described in 1970, anterior open bite might also be a result of increased axial inclination of maxillary and mandibular incisors. The treatment of any particular open bite problem naturally would be dependent on the particular problem list evolved with the assessment of each individual patient.

Insoft and his colleagues (69) reported that several factors have been implicated in the cause of anterior open bites, including unfavorable growth patterns, digit sucking habits, heredity and an enlarged lymphatic tissue. Several studies have found correlations between orofacial musculature and facial structure and indicated relations between weak musculature and long face and anterior open bite patterns. Concrete establishments of cause-effect relations is much more elusive, however; these are classic "chicken or egg" questions. The problem in many patients may well be multi-factorial, and subsequent problems that appear similar may have different causes.

In a recent article Shapiro (101), reported that as would be expected, the etiology of open bite malocclusion varies, but a number of factors have been generally associated with the problem: growth pattern, digit sucking habits, abnormal tongue function or posture, nasal airway obstruction, mouth breathing, and abnormal mandibular or head posture. Although excessive vertical growth might be associated with anterior open bite, many patients have long faces and deep overbites, and some with normal skeletal patterns have persistent open bites. Digit sucking, as with any physical interference with tooth eruption, can cause anterior open bite. If the habit is discontinued and the open bite remains, then one must suspect abnormal tongue posture or function. As mentioned above, the resting posture of the tongue is probably more important than its function during swallowing. Partial nasal airway obstruction, caused by any number of problems, including allergies or enlarged adenoids, may be related to anterior open bite, but many patients have those problems without open bites.

To study the growth factor effect in more details we refer to Schudy (100) who stated that horizontal forward growth in the mandible, is primarily due to condylar growth, while the vertical growth is due to either growth at the Nasion,

growth of the maxillary corpus itself, growth of the maxillary alveolar processes causing the molars to move away from the palatal plane, and or growth at the mandibular posterior alveolar processes causing the molars to move occlusally. If the vertical growth in the molar region was greater than that at the condyles, the mandible rotates in clockwise direction increasing the anterior facial height, less horizontal change of the chin happens thus increasing any Class II condition, and in extreme cases causing anterior open bite. In the same study he found that in non treated patients 70% of the vertical growth was due to maxilla, half of which was in the maxillary corpus, and the other half in the alveolar process, and 30 % in mandible.

Facial growth has been believed to proceed along a vector composed of variable amounts of horizontal forward growth, and a vertical downward growth. The relative proportions of forward growth and downward growth have been characterized as relatively constant for a given individual (46), producing a constant vectorial direction of facial growth. Thus facial angles and linear measurements may increase in size, but were considered to stay stable in proportion (12). Facial sutures, maxillary and mandibular alveolar processes, and mandibular condyles are known to be major sites of bone addition. Since the mandible possesses an articulation with the skull, it is clear that if the vertical growth anteriorly, in the facial suture and alveolar processes would be more than that in the condylar area the mandible would rotate backwards and downwards (46).

To study the effect of heredity and growth in open bite, Bjork and his colleagues (8,9) used metal implants in the jaws in order to accurately superimpose cephalometric x-rays. They found that facial growth occurred in rotations, and that much of the changes are masked by the resorption and remodeling happening in the jaws. Malocclusions, they said, are to a greater extent due to incomplete compensatory guidance of eruption than to dysplastic deformation on the dental arches. They observed two instances where downward and backward rotation of the mandible occurred and lead to increased facial

height, and possibly open bite. One is when the bite is raised by orthodontic means or change in intercuspation. The center of backward rotation in this condition is the TMJ, and it results in an increase in anterior facial height. It could also happen if there was flattening of the cranial base, so that the middle cranial fossa is raised and the mandible is raised too. The second type was when the growth in the condyle is sagittally directed, and not due to any molar over extrusion. The sagittal growth curves increasingly backwards and the center of rotation in the second case lied at the most distal occluding molar. It resulted in an increase in the forward inclination of lower molars and premolars and a decrease in the interpremolar and intermolar angels. As it was quite easy to lose anchorage in these cases, and also they are negatively affected by growth, Bjork advised against early treatment in these cases as it might increase the open bite. Bjork (8) mentioned 7 signs that could help to predict the type of rotation that could happen in the mandible: inclination of the condylar head, curvature of the mandibular canal, shape of the lower border of the mandible, inclination of the symphysis, interincisal angle, interpremolar and intermolar angles, and anterior lower facial heights. Straight or sloping upward and backward condyle, straight mandibular canal, notched mandibular lower border, forward slope of the symphysis, acute interincisal angle, acute interpremolar and intermolar angels, and increased anterior facial height, all are considered signs of a backward rotating mandible.

Isacsson et al (47) stated that growth rotations could happen due to dissimilar increments of vertical growth between the mandibular condyle and fossa on one hand, and maxillary sutures-alveolar process on the other hand. Thus a downward and backward mandibular rotation would happen if the vertical growth at the alveolar processes exceeded the vertical growth at the condyle.

Mandibular growth rotation is not only affected by the amount of growth happening at the condyle, but it is also affected by the direction of growth of the condyles. This growth could be vertical, sagittal, or any direction in between. Vertical condylar growth will cause resorption at the angle of the mandible and

apposition in the symphysis area in order to maintain a constant relation between the mandibular plane and the cranial structures. Conversely when the condylar growth took place in a posterior superior direction apposition occurred at the mandibular angle and resorption at the symphysis occurred in order to maintain the constant relation between mandibular plane and cranial structures (76).

Vertical skeletal growth discrepancies include vertical eruption of the maxillary molars and or alveolus, that subsequently hinges the mandible downward and backward, under development of the middle cranial fossa height, producing an elevation of the glenoid fossa, and inadequate alveolar growth in the anterior portion of the maxilla (4).

The long face syndrome is characterized by a pronounced increase in the lower facial height. Shendel et al (98) investigated this condition. They used many names that were used to describe this condition in other literatures: Extreme clock wise rotation, high angle type, adenoid face, idiopathic long face, total maxillary alveolar hyperplasia, and vertical maxillary process. The common dominator was always excessive vertical growth of maxilla. Despite this, they observed that there were two types of this condition, one of them was with an anterior open bite and the other was without an anterior open bite. While both shared common characteristics such as long face, narrow nose, narrow alar bases, excessive exposure of upper lip and gum, retropositioned chin, and high palatal vault, they both differed with respect to ramus length. The open bite cases had normal ramus length while the normal bite group had longer ramus length. In these long face cases, more posteriorly directed growth pattern of the mandibular condyle expressed as vertical growth at the chin is found. The mandibular position is affected by the anterior and posterior facial height growth. Differences between the anterior facial height and posterior facial height growth lead to rotational and positional changes in the mandible that greatly affects the position of chin. Anterior facial height is generally affected by the eruption of the maxillary and mandibular posterior teeth, as well as the amount of sutural lowering of the maxilla. As for the posterior facial height it is most affected by the lowering of the

temperomandibular fossae and condylar growth, backward and downward rotation of the mandible occurs, leading to an increased anterior and lower facial height and the development of long face syndrome.

The question arises as what really induces these differences in growth to happen. The answer would be also of multi factorial origin. Genetics and heredity are major causes, but also many functional, postural, and growth related factors have been identified. Some investigators noted that weaker masticatory muscles are present in high angle cases and hypothesized that this less biting force might be a factor in developing a long face (44), others (107) have attributed this to nasopharyngeal obstructive disorders such as allergy, septum deviation, and large conchae. These conditions could force the mandible into a lower position to open the air space, and thus affect the growth accordingly.

Other researchers have noted that backward rotating mandibular growth pattern is caused by overerupted molars rotating the mandible downwards backwards away from maxilla, and thus leaving the already over erupted anterior teeth in open bite. Nahoum (74), on the other hand, found that the molars were generally not over erupted in open bite cases, and thus he believed that short ramus length, and less than normal posterior facial height were the real causes of open bite.

Others noticed a large sequence of events that are happening at the same time during growth and every one of them affects the others leading to the development of open bite condition. According to Sassoni (97) the posterior half of the palate is tipped downwards, carrying the molars further downward. This gives rise to a large palatomandibular plane angle. Increased development of the upper midfacial height (cranial base to molars) and lack of development of posterior face height (S-Go) result in the downward backward rotation of the mandible. Because of the short ramus, and the lower palate, the pharyngeal space is constricted. So, in order to breath, these patients keep their tongue forward. Further enhanced by dental open bite, there is a tongue thrusting

tendency. When enlarged tonsils are present, the tongue is further confined anteriorly. As the narrow palatal vault reduces the necessary space, there is a tendency toward tongue protrusion.

To discuss the effect of abnormal muscular and soft tissue activity in more details we noticed disturbance in growth like neurologic, CNS disorder problems due to injury, disease or mal development can result with an open bite due to impaired neuromuscular control of the tongue leading to anterior open bite. This fact was demonstrated by establishing that there was a higher incidence of open bite malocclusion among mentally retarded and mongoloid children (71). Gershater (29), found a significant number of open bite malocclusion 32.2% among mentally retarded and emotionally disturbed children in one of his study groups. He attributed the cause of open bite in these cases to the higher incidence of poor neuromuscular patterns and pernicious oral habits.

Igervall (44), found a correlation between the shape of the face and the muscle activity during chewing and swallowing using an EMG appliance. In long face people he found the strength of the temporal muscles were weaker than people with short rectangular faces. Whether this was a cause of open bite or a result of it was not verified.

In a recent study, Pae et al (77), studied the air way length and found it to be associated with anterior open bites. In their article they studied 58 patients with long face and steep mandibular plane angle and found that vertical airway length, measured from the posterior nasal spine to base of epiglottis was associated with anterior open bite cases from that group of patients. They concluded that pharyngeal length maybe a convenient indicator of open bite. They also found that the hyoid bone was positioned relatively lower in cases with upper airway obstruction. This lower position provided the tongue with space to move inferiorly, and thus opened more space for respiration. Based on these clinical observations they thought of two ways that open bite can result from airway obstruction. Either, the genioglossus muscles would protrude the tongue

and thus their elevated tonic activity in response to the airway resistance may cause open bite. Or the encroached vital pharyngeal space because of tongue mass or adenoid tissue would stretch the cervical spine. The stretched cervical spine would pull the hyoid bone posteriorly and the tongue inferiorly. The tongue and mandible rotate backward, encouraging mouth breathing. Habitual open mouth posture could cause the posterior segments of maxilla to overgrow and cause open bite.

If an anterior open bite is seen in early age it is most probably due to a habit problem.

Proffit (81) reported that the development of open bite in thumb sucking children correlates most with the hours per day sucking rather than the magnitude of pressure. Children who suck vigorously but intermittently may not displace the incisors much if at all, whereas those who produce 6 hours or more of pressure, can cause a significant mal-occlusion.

Thumb sucking, up to a certain age 4-5 years can be considered normal (71), but after that age, if the habit persists then there is a strong possibility that it can affect the normal development of the bite. Problems that can arise from thumb sucking are: obstruction to the eruption of anterior teeth and development of anterior open bite, also proclined upper teeth and a V shaped upper arch could result from this habit. And due to the excessive pressure applied by the cheeks during thumb sucking, narrowing of the arch at the molar area is frequently observed. Also thumb sucking habit could affect the lower teeth so they will be slightly depressed and lingually inclined (71). The earlier the cessation of the habit occurs the better, and if did not cease we should use a habit breaker to effectively stop this habit. Swinehart (111) noted that this habit is mainly in the anterior region where 85% of open bite happens. He added that when more fingers are included open bite can extend to the molars. He also observed that forces acting during thumb sucking were upward and forward against the maxillary anterior teeth with little downward pressure on the lower teeth, thus

explaining the frequent infraclusion and protrusion of the upper incisors and slight infraclusion of the lower ones. In a previous study about thumb sucking the author (111), has found that 80% of thumb suckers had open bites and also many adult open bite cases presented early histories of thumb sucking habits. He believes that thumb sucking habits encourages abnormal tongue actions and thus plays an originating role for open bite development. According to Parker (78), the anterior space created by the thumb sucking habit will make the tongue advance in swallowing to close the space and thus the bite may well still be open even if the thumb sucking habit ended. As the habit ceases the open bite gradually disappears, and self correction happens, unless the habit stays long enough to cause permanent changes that would require active treatment to resolve. Its worth mentioning here that Straub (106), argued that abnormal swallowing is not caused by a habit like thumb sucking but in fact is due to the habit of bottle feeding infants especially using long and multi holed nipples which positions the infant tongue under it and by this starts the abnormal swallowing habit.

Much attention has been paid at the various times to the tongue and tongue habits as possible etiologic factors in mal-occlusion, and this received particular emphasis during 1950s and 1960s.

Tongue thrust, infantile swallowing and reverse swallowing all describe the condition where swallowing happens while the anterior teeth are in apart. During the act of swallowing the tongue positions itself between the anterior teeth to fill the gap and achieve an oral seal with the contact of the lower lip. Swinehart (111), in early forties stated that abnormal size and form of the tongue when associated with anomalous action seemed to be the cause of extensive open bite in all classes and abnormal action in deglutition apparently was the originating cause and the perpetuating cause in open bite cases. During the sixties, it was considered as the main cause of open bite condition and many orthodontists began their treatment with tongue crib appliance, speech therapy, and tongue exercises. Straub (106) stated that this abnormal swallowing habit was not due to

any habit such as thumb sucking but was caused by improper bottle feeding in infants. He described many cases with abnormal swallowing many of them presented with a narrow maxilla and a high and narrow palate due to downward tongue position, as well as protruded upper teeth and open bite anteriorly. He also found various other cases of lateral open bites or multiple diastemas which were caused by abnormal swallowing. He insisted that this habit will not disappear with time unless proper habit control measures like habit breakers or lessons have been done. The author also questioned the validity or effect of such measures when done on adult patients. Atkinson (3) described this swallowing with teeth apart condition as if the patient was swallowing while trying to avoid a sore throat. He noted that this type of swallowing occurs also in patients with large scars due to past adenoidectomy or tonsillectomy. Using motion pictures to film the face while swallowing he described the huge forces that are interacting around the oral cavity while swallowing. He compared this type of swallowing with infantile type swallowing. In infants there are posterior stops and no teeth. In these conditions the masseter, internal pterygoids, and temporalis muscles are under tremendous contraction making the gonial angle more obtuse. At the same time the supra and infra thyroid muscles contract to pull the chin downward and exaggerating the antegonial notch. But as the patient grows and as the molars erupt the pattern of swallowing changes and there is a stop to the upward pull on the mandible in the area of the lower border of the ramus.

On the other hand in abnormal swallowing the tongue positions itself between the anterior teeth and thus disoccludes the posteriors. This will apply huge forces on muscles and jaws and result in an anterior open bite. Some researchers have measured the muscular forces during the acts of swallowing using EMG appliance. In a case presentation (59), it was found that the open bite case had very little activity of the anterior temporalis during swallowing while at the same time increased activity of the genioglossus and inferior orbicularis oris muscle which shows how much the patient has to force and stress his facial

muscles in order to achieve the seal necessary for the swallowing while his teeth were apart.

More recently many researchers have challenged this theory. Many studies have been done and showed that there are many normal patients that lack any mal occlusion but have tongue thrust and imbalanced perioral muscle activity. It was found also that tongue thrust swallowing is the main method of swallowing before ten years of age (24). Also although the tongue thrust patients have more tongue pressure and less lip pressure thus implying that the resultant forces would affect the teeth in a bad way, but it was also found that these patients swallow half the average time of normal people (63). Other studies showed that between 1500 eleven year old children only 2.7% had tongue thrust, and only half of them had malocclusion (114). Generally as the patient changed from the infantile to normal swallowing the open bite spontaneously corrects itself upon growing up. Spiedel et al (104), believed that abnormal form induces abnormal function and this is why it is thought that tongue thrust is a compensatory mechanism to achieve an oral seal during swallowing. As the abnormal form is corrected it was also found that the tongue adapts and accommodates itself to the new position and in some cases it was even reported that it decreases in bulk, like after surgery. This was demonstrated by an informal evaluation of post surgical results in over 100 cases treated with surgery. No case showed any sign of flaring in teeth or spacing due to tongue because of smaller post surgical environment (104).

Finally, Proffit (81), noted that the tongue posture is much more important than the tongue thrust in the development of open bite as it has a longer duration of time. Although the force of thrusting could be large but it is the posture that has the upper hand in determining the long term effect in open bite development and not temporary tongue movements. Tongue thrust swallowing simply has too short duration to have an impact on teeth position. Pressure by the tongue against the teeth during a typical swallow lasts approximately for 1 second. A typical individual swallows 800 times per day while awake, but has only a few

swallows per hour while asleep, the total per day therefore is usually under 1000. one thousand second of pressure, total of few minutes, not nearly enough to affect the equilibrium.

Kim (57) attributed anterior open bite cases to the mesial inclination of the posterior teeth which makes a wedge and thus opens the bite anteriorly.

The list is long and there is evidence in the literature supporting each one of these factors which led to the development of many treatment protocols for the correction of this condition.

4.1.4. Treatment Modalities

Open bite malocclusion has long held great fascination in orthodontics. It is difficult to treat, and relapse tendencies are strong. Valid or not, numerous articles and seminars have been presented to espouse various treatment modalities, depending on the etiology ascribed to the open bite malocclusion by the orthodontist.

A tongue crib or lingual prongs are widely advocated in these cases because the malocclusion is often thought to be caused by a tongue thrust. The early sixties to the mid-seventies could be called the 'era of tongue thrusts,' when it was emphasized to such a degree that some orthodontists did not even examine a malocclusion unless the patient had first received therapy for tongue thrust. Even where tongue thrust is a factor, if it should be of neurologic or pathologic origin, a mere tongue crib or speech therapy cannot produce successful correction (110).

Tongue thrusting during the eruption of permanent incisors can be a natural phenomenon. When there is a vertical gap during incisor eruption, the tip of the tongue may be placed between the upper and lower incisors in deglutition to contain the bolus. Fortunately, most children avoid or soon overcome this altered function as the incisors erupt into normal relation (57).

The great success often claimed for tongue crib or speech therapy for open bite during the mixed dentition stage is often based on changes that would have otherwise occurred spontaneously with growth. Active habits such as thumb or finger sucking are exceptions, in which therapy must be based on the severity and history of the habit.

If a functional appliance or a tongue crib, or even tongue-thrust therapy, had been used at that time without adversely affecting the child's behavior, it could have been claimed that the treatment produced this correction.

High-pull headgear is another common approach to open bite treatment. The rationale for this therapy is to intrude maxillary molars that are considered to be extruded. Can intrusion of the entire molar segment be accomplished to a sufficient degree with high-pull headgear to correct an open bite? Kim (57) has been unable to find cephalometric evidence of any measurable reduction of the distance from the molars to the hard palate.

Chin cap is applied to anterior open bite with a similar objective, typically when the problem is described as the long-face syndrome or adenoid faces. The projected remedy is to reduce the "long" face into a more "normal" face by means of chin cap traction.

Vertical elastics in the anterior region are another common approach, the objective being to close the bite by extruding the incisors. On superficial examination in the short term, it may look as though the open bite has been corrected. However, mere extrusion of the incisors cannot produce a stable relationship, so the teeth commonly relapse from such a temporarily improved appearance.

Ultimately, in the face of an unsatisfactory prognosis or absence of any viable treatment choice, these cases may be simply designated as "skeletal open bite" or "a surgical problem." Some type of surgical approach has become a popular method of treatment for open bite, for it can present a rapid and

admirable esthetic result. Nevertheless, it can be difficult to justify the surgical risk and trauma, especially when permanent correction still cannot be assured.

Of course, there are cases that present severe skeletal aberrations that do warrant surgical correction, but many patients do not fall into this category. It is difficult to justify full Edgewise appliance therapy combined with surgery to correct a small open bite when the result may include even such a "minor" sequella as permanent paresthesia or paralysis of parts of the face, regardless of the technical perfection of the immediate occlusal result. (57)

Because of the variety of theories on cause, a wide variety of treatment philosophies have been advocated for the correction of anterior open bites. Many orthodontists believe that without identification and elimination of the etiologic factors, treatment and stability will have a poor prognosis.

This in turn led to the advocacy of speech therapy, tongue retraining exercises, and habit appliances as a part of the orthodontic armamentarium (6, 70, 78, 85). A variety of removable and fixed appliances have been developed to counter digit sucking and tongue habits, for example, obstructive cribs, various acrylic plates, and palatal spikes (44, 78, 106). Some orthodontists claim success from orthodontic means alone. Cooke et al (14) presented a case in which they extracted molars, thus moving teeth out of the "wedge" thereby causing an upward and forward autorotation of the mandible. Kim (57), on the other hand, believes the key to success lies in the axial inclination of the posterior segments that must be upright in relation to the occlusal plane. He advocates the extraction of second or third molars and distalizing the crowns of the first molars through a technique called multiloop edgewise arch wire. In addition, while others have had little success in using the chincup and headcup, Graber (34) has found that in his practice it renders the best response. High-pull headgear to the maxillary molars is another common approach to open bite treatment. The rationale for this treatment is to intrude the maxillary molars and allow the mandible to autorotate, thereby closing the anterior open bite; some authors may dispute this (5).

Before the 1970s, treatment consisted primarily of dentoalveolar changes or modification of oral habits. While this may be adequate for some dental open bites, it is inadequate for the treatment of skeletal open bites (2, 14, 86). Several surgical techniques were developed to aid in the correction of anterior open bites, including three-piece sectioning of the maxilla (41), subapical osteotomies (113), and corticotomies (28). Recently, repelling magnets in posterior bite-blocks have been used to intrude the posterior segments, allow autorotation of the mandible, and thereby close the open bite (15). Kiliaridis et al (54) conducted a study of 20 growing patients, age 9 to 16 years, with skeletal anterior open bites. Half of the subjects wore removable repelling magnetic posterior splints, whereas the other half wore removable acrylic posterior bite-blocks of the same thickness. The results showed that the magnets caused a more rapid intrusion of the posterior segments.

While magnets have been shown to close open bites in some cases, there may be at least some patients for whom they might not be the best treatment in the long run. Many patients with open bites seem to have hypotrophic or hypotonic masticatory musculature. Relative to average persons, their mouths seem to hang open flaccidly. As anyone who has ever tried to push the opposing poles of two-magnets together has noted, such magnets produce a "noxious" sort of force that might encourage some open bite patients to let their mouths hang open all the more, avoiding the magnets rather than fighting them, and discourage them from using their masticatory muscles, leading to their further weakening. Weaker muscles would not contribute to the stability of the result; stronger muscles would.

Parker (78) noticed that some of the open bite cases were self correcting. He found that many of these self correcting cases took place in the transition period between mixed dentition and permanent dentition when the posterior teeth were lost. The tongue automatically expanded laterally to make a seal in the swallowing act, thus the tongue thrust habit faded away and the anterior teeth and alveolar bone were free to erupt normally.

Nahoum (75) noted that many of the early open bite cases caused by obstructed eruption of the anterior teeth showed spontaneous remission without any form of treatment. It has been proved before that young patients at the age of 6 have approximately double the incidence of open bite compared to older ones at 17 years of age. The reason is the habits that are seen in young, such as the thumb sucking habits in addition to the tongue thrusting way of swallowing which is more common in young age. As these population grows these habits gradually disappear and thus the open bite gradually self corrects. In cases where the habit persists or the patient is needing help in stopping his habit, habit breakers can be used.

Crib therapy for thumb sucking habit is one type of treatment, fixed or removable crib appliances have been tried with obvious goal of stopping this habit although it was documented that using a removable appliance for such a purpose could be questionable if the patient did not really want to stop the habit. (71) The crib is vertically disposed extending from the palatal region completely encompassing the anterior open bite, and resting close to the gingival area lingual to the lower incisors where the posterior teeth are in occlusion. In this position it serves as a complete mechanical barrier to the thumb or fingers. In addition it will prevent the tongue from coming forward into the anterior open bite region during function.

It has been shown (81) that 50% of these thumb sucking patients stopped their habit immediately, while at the end, a total of 85-90 % of these patients stopped their habit, and it has been advised to leave the crib in place for 3-6 months after the habit has been ceased as a safety retention measure. Crib for thumb sucking and for tongue thrusting can be with spikes or without spikes. Many authors such as Gershater (39) strongly advised using the ones without spikes and were concerned about the adverse psychological effects of the spiked appliances.

In patients with tongue thrust, tongue cribs (49, 106) and tongue spikes or spurs were used. They were constructed using bands on molars or even just banding the anterior incisors while electrically soldering sharp prongs protruding downwards and backwards during closure so that they can effectively prevent the tongue from being anteriorly and downward positioned (78). Spurs were also added lingual to lower incisors for the same purpose of controlling tongue posture (103). It is worth mentioning here that some researchers discouraged the use of the spiked appliances fearing of complicated psychological consequences and trauma to the patients (71). While others stated that if the appliance was correctly made and the patient effectively encouraged it will not have any adverse effect or trauma effect (78).

Myofunctional therapy, speech therapy, and tongue exercises were also used. The use of myofunctional therapy was more effective in young patients but as the age increased it got more difficult to achieve acceptable results.

Nahoum (75) noted that nearly all the patients can be taught to swallow without tongue thrusting in a voluntary level. But he added that swallowing happens mainly on a subconscious level and that swallowing occurs 1200 to 1500 times a day. Which raised the doubt about the effectiveness of this type of treatment. Other researches have shared his doubt and advocated the treatment of the dental and alveolar problems in order to provide an acceptable environment for the tongue to adapt to, while questioning the ability of the tongue retraining and myofunctional therapy to achieve any results in older patients (48).

Parker (78) found speech therapy only partially effective and in many cases it failed to attain responses.

Gerashter (29) found that there were higher speech problem in open bite cases than in normal cases, and so found speech therapy unnecessary. Proffit (81) went to the extent of questioning the need to do any myofunctional therapy or exercise the tongue.

After the habit was eliminated the open bite ceased unless there was another factor in causing the open bite development.

Frankel and Frankel (25) recognized the relationship between the postural behavior and skeletal deformities. They hypothesized that the deficiency of an oral seal might be due to a poor postural behavior of the facial muscles particularly the lip area. and noted that the faulty position of the tongue was an adaptive measure to achieve an oral seal. They emphasized the need to build up strength in the perioral area and masticatory muscles in order to get a beneficial and stable result. And aimed at overcoming the deviant facial pattern of mandibular rotation through reestablishment of nose breathing by correcting the lips apart condition and faulty tongue posture. And so they used Frankel IV appliance which contains vestibular shields and added lip exercises to strengthen the lips and musculature. In the same study no change in the molar position was found. No intrusion happened, but an increase in ramus length was observed. They reported a more favorable growth pattern in treated cases while the non treated cases stayed the same or get worse. These findings were also stressed in a study by Erbay et al (22) as the overbite increased significantly in treated cases the posterior facial height was also reported to be 1 mm more than the increase in non treated cases.

Other appliances that aimed at controlling the vertical dimension were acrylic bite plates, magnetic biteplates (15, 58, 91), and spring loaded biteplates (19, 91). The presence of these bite plates prevented the eruption of the posterior teeth, and applied active force for the intrusion of the posterior teeth. This active force is the result of the imbedded repelling magnets, the spring, and or the effect of the stretching of the masseter and other elevator muscles. This vertical force served to control the eruption or even intrude the posterior teeth and thus helped to control or treat the anterior open bite. Dellinger (15) introduced a magnetic acrylic appliance that he named Active vertical corrector. He reported intrusion of molars in his cases. Open bite was closed due to the intrusion and mandibular favorable rotation and decrease in anterior facial height.

He followed these cases up to three years and claimed stability of results. In another study Dellinger et al (16), presented 5 patients treated with active vertical corrector many years after the end of the treatment they showed stability of open bite closure. The use of active vertical corrector appliance , was also studied in another research by Barbe and Sinclair (4). They reported treatment of open bite cases mainly due to molar intrusion and partially due to incisor extrusion and retroclination. The amount of intrusion that they reported was 0.6 mm in upper molars and 0.4 mm in lower molars.

Karla et al (58) used a fixed magnetic appliance on ten patients 8-10 years old. 4 months of treatment was done and they reported an intrusion in all of the maxillary and mandibular teeth of about 1.5 mm. They also reported a forward upward rotation of the mandible., but they also mentioned that a small rebound of the intruded teeth happened after treatment .

In a study to compare the effects of magnetic and spring loaded bite plates (91), the spring loaded appliances were found not to cause any molar intrusion. The positive postural changes were attributed to slight eruption of incisors and less than normal eruption of molars. As for the magnetic bite planes, a forward and upward rotation of the mandible was seen but it was also noted that it relapsed fairly easily. Both appliances did not affect the maxilla and effects were mainly in the mandible.

Also the use of chin cap therapy has been attempted to close the open bite by decreasing the anterior facial height (1, 32). Graber (32) used heavy forces on the mandible by the means of a chin cap in order to alter the direction of growth of the mandible. He achieved a marked reduction in anterior open bite. Cangliosi (12) advised the use of chin cap accompanied by posterior bite blocks in order to treat these cases. High pull head gear to control the maxillary growth also have been used.

Some researchers (116) advocated the use of implants. They presented 2 anterior open bite cases treated by intrusion of the lower molars with the help of mini implants in the mandible and elastic modules. They reported 3-5 mm of intrusion in the lower molars. Another thing reported was that the lower and upper incisors were extruded about 2 mm each.

In another very recent study Erverdi et al (23) assessed the effectiveness of zygomatic anchorage for the intrusion of maxillary posterior teeth. They treated a male patient, 20 years 5 months of age, with 3-mm anterior open bite with excessive maxillary posterior growth using Titanium miniplates which were fixed to the buttress area. This zygomatic site was used for both upper molar intrusion and canine distalization. In their study upper molars were intruded 3 mm. They stated as a conclusion that the zygomatic area is a useful anchorage site for the intrusion of the molars over a short period of time.

Some other methods advocated the extraction of premolars (105), and consolidation of the anterior teeth. The method is especially used when the case is suffering from excessive incisor proclination or excessive overjet. There are two mechanics in this treatment method that help in the closure of the anterior open bite. Mesial movement of the molar teeth which can result in reduction of the mandibular plane angle with a resultant closure of the open bite, and the retraction of the incisors resulting in uprightening and relative extrusion as the crown is retracted below the center of rotation. Extraction of molars (14) also has been advocated as it would move them out of the wedge and thereby causing and upward and forward auto rotation of the mandible.

Also some earlier researchers (107) even went to the extent of advising against orthodontic treatment if the case was a real skeletal one in a grown up patient. They stated that "in some cases the best treatment may not be to attempt orthodontic treatment".

Many types of surgeries (64,105,118) were described mainly the maxillary impaction surgery with mandibular counter clockwise rotation approach was advised as this approach would have better esthetic results on the face of the patient (30,51,93). The maxillary surgery can be done as a Le Forte 1 surgery with either one or three piece osteotomy if expansion was needed during surgery. Mandibular surgery could either be needed or in some cases not. It could be a bilateral sagittal split ramus osteotomy , a genioplasty, a subapical osteotomy, or all together. Surgery is considered the treatment of choice in severe open bite cases in older patients and is believed to have the advantages of better esthetic and more stable results (105).

One of the methods available for the treatment of open bite is the multiloop edgewise arch wire technique developed by Kim (57). This technique involves the use of multiloop gable bend arch wires with vertical elastics in the canine regions. The goals of this technique include correction of the inclination of the occlusal planes, alignment of the maxillary incisors relative to the lip line, and uprighting of the axial inclinations of the posterior teeth. Using this technique, Goto et al (31) and Sato reported successful treatment outcomes.

Enacar et al (21) modified Kim's technique by using 0.016 × 0.022 inch upper accentuated-curve and lower reverse-curve nickel titanium arch wires instead of multiloop gable bend arch wires, with the intermaxillary elastics applied in the canine regions. They suggested that upper accentuated-curve and lower reverse-curve nickel titanium arch wires were simpler and more hygienic compared to multiloop arch wires, they reduced chair time, and did not irritate the soft tissues. Enacar et al reported that their results were similar to those obtained by the multiloop edgewise arch wire system.

Kucukkeles et al (62) studied a group comprised of 17 patients who displayed a high angle skeletal pattern, along with an anterior open bite. After initial leveling, 0.016 × 0.022 inch upper accentuated-curve and lower reverse-curve arch wires were placed, with anterior elastics applied in the canine regions.

Cephalometric assessment was carried out on lateral head films taken at the beginning of treatment and on average 2.8 months after open bite closure was obtained. The results of this study indicated that open bite closure had been achieved mainly by extrusion of the lower incisors and uprighting of the upper incisors. The functional occlusal plane was leveled by extrusion of lower premolars and uprighting of lower molars. Lateral cephalograms obtained from 10 patients who had been available after 1 year post retention were used to evaluate relapse changes. During the follow-up period, position of the upper and lower incisors and the inclination of the occlusal plane were maintained. However, extrusion of upper and lower molar teeth resulted in a reduction in overbite.

Anterior box elastics were used to extrude the anterior teeth, while other methods have been applied to attempt the intrusion of posterior teeth. Multiloop edgewise arch wires, with anterior up and down elastics, aiming at the correction of the mesial tilt of the molars and thus removing the blockage and wedge effect caused by them, were advocated by Kim (57). The closure of the open bite was achieved by the correcting the mesial tilt of the molars and approximating the upper and lower occlusal planes as well as some extrusion of the anterior upper and lower teeth. At the same time an increase in the lower facial height and eruption of molars was seen. Accentuated upper curve with lower reverse curve arches and anterior box elastics that attempted the intrusion of the posterior segments as well as the extrusion of the anterior one have been documented also. The advantage was the use of the Ni-Ti wires was easier, more hygienic and less irritative to the soft tissues of the patient while consuming less chair time. As the anchorage was very critical in the previous methods, and frequently incisors were over erupted while the molars were not effectively intruded,

4.1.5. Stability

Lopez et al (68) evaluated the cephalometric radiographs of 41 patients (29 females, 12 males) pretreatment, immediately post treatment, and 10 years

post retention. At the beginning of treatment, they were adolescents in the permanent dentition who had a Class I or II malocclusion. Each had an open bite of at least 3 mm measured along the long axis of the mandibular incisors. They were treated conventionally with fixed appliances, headgear, and elastics. In the long term, 35% of the patients had an open bite of 3 mm or more, and 65% had relatively stable results. Because of concerns that the measurement of the open bites in this study was unduly influenced by the angular and anteroposterior position of the mandibular incisor, the study was redone a few years later by Zuroff (120). He expanded the sample and subdivided the subjects into 3 groups: a contact group of 24 with an average overbite of 4.79 mm, an overlap group of 25 with an average overlap of 1.80 mm, and an open bite group with an average overlap of -2.23 mm. The overbite measurement was made relative to the nasion-menton line. At 10 years postretention, 60% of the open bite subjects did not have incisor contact. On the other hand, in the entire sample of 64, the largest vertical relapse was 2.4 mm, and no one had negative incisor overlap. In the subjects who showed instability of overbite correction, the mandibular incisors failed to erupt vertically as they continued to move lingually (with increasing crowding). As with Lopez's study, analysis of pretreatment records did not allow stability or instability to be predicted in the treatment result. Katsaros and Berg (52) evaluated 20 patients who had pretreatment open bites as determined from plaster casts. The open bite, measured perpendicular to the nasion-menton line, was an average of -1.9 mm. Nineteen of the patients were treated with edgewise appliances and 1 with a functional appliance. They were evaluated at least 1 year post treatment. The criterion for successful treatment was the presence of occlusal contacts of at least 2 incisors in habitual occlusion or after forward sliding of the lower cast. On that basis, 15 of 20 patients (75%) were treated successfully. Huang et al (43) studied the stability of crib therapy in open bite patients. The sample included 26 growing and 7 nongrowing patients who were evaluated cephalometrically before treatment, at the end of treatment, and at least a year post treatment. Before treatment, the average negative overbite, measured relative to the nasion-menton line, was -2.8 mm. The overall

success rate for achieving a positive overbite was 88%. All patients who achieved a positive overbite during treatment maintained it during the follow-up period.

It is helpful to compare the stability seen in non growing open bite patients treated surgically with that of open bite treatment in children, to give some perspective. Denison et al (17) evaluated 66 patients who had undergone LeFort I osteotomies to decrease facial height. Before treatment, 28 of them had open bites, 24 had overlap, and 14 had deep overbites. Over time, 43% of the open bite patients had a statistically and clinically significant increase in facial height, a decrease in overbite, and an eruption of maxillary molars. Twenty-one percent of the open bite sample relapsed to no overlap. In a recent study, Proffit et al (79) evaluated the long-term stability of open bite patients treated with LeFort I osteotomy. Twenty-eight of the patients had maxillary surgery only, and 26 had maxillary and mandibular surgery. In the long term, overbite decreased 2 to 4 mm in 7% of the maxilla-only group and in 12% of the 2-jaw surgery group. No patient had a change greater than 4 mm. In 75% of those who had a posttreatment increase in anterior facial height, further eruption of the incisors maintained the overbite. The authors speculated that, in the other 25%, incomplete adaptation of tongue posture may have led to a lack of incisor eruption and a tendency for return of the open bite. Previously, Proffit (80) wrote that tongue and lip pressures during function, eg. swallowing, speaking, and chewing, were relatively unimportant as determinants in malocclusion, but that resting pressures might have a significant impact.

Posttreatment changes of open-bite malocclusions have been evaluated by Nemeth and Isaacson (76). They compared the pretreatment, posttreatment, and postretention dental casts and lateral cephalometric radiographs of thirteen persons with open bites that relapsed with records of a similar number of patients with relapsed deep anterior overbites. The maximum postretention interval was 6 years, with a minimum of 1 year and a mean of 3.7 years. In the group with

anterior open bites, the amount of anterior vertical relapse ranged from 0.25 to 7 mm during the postretention interval. They found open-bite relapse to be associated with an increase in posterior maxillary facial height with a significant bite-opening rotation of the mandible. In addition, in the open-bite group, the distance from the maxillary first molar to the sella-nasion plane increased during the posttreatment interval. This posterior alveolar hyperplasia appeared to be related to the rotation of the mandible and subsequent relapse. The amount of vertical anterior relapse varied with the age and growth potential of the patient at the completion of active orthodontic therapy.

The results of a study conducted by Lopez et al (68) showed significant increase in maxillary dentoalveolar development at all time intervals; however, the relapse subgroup did not demonstrate a greater amount of posterior maxillary dentoalveolar vertical development during or following treatment. At all time periods studied, however, lower incisor vertical position was depressed in the relapse subgroup when compared to the stable subgroup.

Frost and associates (26) reported a cephalometric study of thirty-two white women. Nineteen had Angle Class I dental relationships with good dentoalveolar proportions, while thirteen exhibited significant "skeletal" open-bite malocclusions requiring a combined surgical-orthodontic treatment approach. The pretreatment cephalometric radiographs of the open-bite group were compared to those of the control group. Frost and his colleagues noted a greater distance from the palatal plane to the apex of the maxillary first molars indicative of a posterior vertical maxillary excess, in the open bite patients. They concluded that this type of vertical dentoalveolar dysplasia was related to a bite-opening rotation of the mandible, resulting in an increased mandibular plane angle, a reduced SNB angle, and a greater lower anterior facial height.

Isaacson and associates (46) have suggested that in order for the mandible to compensate successfully for dental eruption, there must be an adequate amount of vertical condylar growth. Overcompensation can lead to a

decrease in the ANB angle and a deepening of the bite, while undercompensation may cause anterior bite opening.

Evaluation of the long-term response of mandibular incisor alignment demonstrated considerable relapse over time. In confirmation of the report by Little, Wallen, and Riedel (67) of sixty-five treated cases 10 years out of retention, the majority of cases in the present study also demonstrated substantial lower anterior crowding over a long postretention period. Subdividing the sample into stable and relapsed open bites did not reveal any significant differences in behavior of incisor alignment following treatment. As anticipated, arch width and length decreased during the postretention interval.

Posttreatment changes appear to be a multifactorial problem. Parameters such as the interrelationships in skeletal, sutural, and dentoalveolar vertical development, undoubtedly play a major role in determining posttreatment stability. The determinants of vertical tooth relationships are not completely understood; however, it is speculated that open-bite relapse is related to disharmony in maxillary dental height changes and vertical skeletal facial changes during and following therapy.

In a cephalometric evaluation of the effect of Ni-Ti wires and the anterior elastics it was found that the bite opens after the treatment due to continuous upper and lower molar eruption which caused a decrease of 1.25 mm in the overbite 1 year into retention.

Kim et al (55), in a retrospective study of patients treated with the multiloop edgewise arch wire therapy found no significant relapse of the treatment after 2 years of retention. His patient groups were divided into growing and non-growing groups and both of them had no statistically significant relapse reported.

Dellinger et al (15), followed 5 of his patients long term and found stable correction.

On the other hand, relapse was found to be much less in cases treated with surgery, as was found by Schendel et al (105), who studied 30 anterior open bite patients treated with surgical technique and followed up to 14 months post operatively.

As a measure to strengthen stability and prevent relapse of open bite, Sheriden et al (102) used a force amplified retention method. They used conventional cuspid to cuspid upper and lower lingual retainers, with low profile bonded lingual special retainers and intra oral elastics. As the open bite was usually finished or closed at the end of the treatment, they hypothesized that most of the relapse was due to inadequate time for the tongue and oral structures to adapt. Thus elastics were used as long as possible in retention to stabilize the closed bite and if they were discontinued and the bite opened, they could always be put again. They were worn only at night.

Other methods used to control relapse were overcorrection, use of positioners, use of chewing gum (78), and bite blocks etc. Nonetheless, anterior open bite is still considered as a difficult entity in orthodontics with difficulties being faced in treatment and retention.

5. MATERIALS AND METHODS

5.1. Case Selection

Our study group was made of 10 patients who applied to Marmara University, Faculty of Dentistry, Department of Orthodontics, seeking orthodontic treatment.

The criteria for selection in our study was:

1. Healthy young patients, with permanent dentition. Maximum age accepted was 14.
2. Patients should have Class I sagittal relationship (slight Class II was also accepted)
3. Patients should have anterior open bite, at least 1mm.
4. Patients should not have significant crowding in their dentition, so that non extraction treatment procedure can be applied.
5. Patients with gummy smile (showing more than 2 mm of the gingival tissue while smiling) were not included in the study group.

The sample consisted of 10 patients (8 females and 2 males). Age ranged from 12.2 to 14 years with an average of 13.37 years in females. And ranged from 13.65 to 14 years with an average of 13.82 years for males. The average age for both groups was 13.50.

All of the cases presented a high angle skeletal pattern (SN-GoMe $> 37^\circ$) and an anterior open bite that ranged between 1 mm and 5 mm with the average being 2.33 mm. Skeletal relationship in the sagittal plane was Class I, and the dental relationship was Class I or mild Class II. All the cases had high angle growth pattern with divergent facial profile, all had downward and backward rotation of the mandible. All of them had relatively narrow palates with over erupted molars. And also had 2 distinct occlusal planes that were only in contact in the molar or premolar area leaving the anterior open.

5.2. First visit and records

For every new patient the treatment procedure was explained as this technique is highly patient dependent. As it is well known if the patient does not use the elastics continuously, the bite will open more, due to the intrusive effect of the wire on the anterior teeth.

After explaining the procedure to the patients and their families, full records were taken which included:

- 1- Full chart including information about the patient, and the clinical analysis.
- 2- Lateral Cephalometric Radiograph.
- 3- Dental casts for the present occlusion trimmed in a symmetric shape.
- 4- Three extra and five intra oral photographs.

The extra orals consisted of frontal, smile and profile.

The intra orals consisted of frontal anterior, right, left side view, plus the upper and lower occlusal.

If the patient went through any other modality of treatment, such as expansion in the upper arch, a new cephalometric radiograph was taken after the expansion procedure was completed.

5.3. Treatment Procedure

After the placement of bands and 0.018 inch slot brackets, treatment was initiated with 0.0175 inch coaxial arch wires. The leveling phase was continued with 0.016 inch round stainless steel arch wires.

After leveling was completed, 0.016 × 0.022 inch upper accentuated-curve and lower reverse-curve nickel titanium arch wires were placed.

We used 0.016 × 0.022 inch reverse curve arches developed by "G & H company, Greenwood. USA" (Fig. 5.1, 5.2, 5.3).

When used without anterior elastics, upper accentuated-curve and lower reverse-curve arch wires create an intrusive effect on the upper and lower

incisors. With the addition of vertical elastics (we used Ormco Z pack elastics, Glendora, California) in the canine regions, the intrusive forces that act on the anterior region were cancelled, while those that act on the posterior teeth were allowed. The intrusive force of the wires on the anterior teeth was counteracted with two $\frac{3}{16}$ inch, 6 oz elastics placed between upper and lower canines on both sides. The patients were instructed to renew their elastics once a day.

Once the open bite in the canine region was eliminated, the elastics were applied in box form until 3 months after incisal overlap was fully achieved. After removal of the NiTi arch wires, 0.017 × 0.022 inch stainless steel arch wires were inserted and kept in place for a period of 3 months, during which box elastics were continued to be worn. Average treatment time with fixed appliances was 12 months. After debonding, positioners were inserted for 6 months, followed by Hawley retainers which were worn for at least 6 months.

Cephalometric evaluation of the treatment changes was conducted on lateral cephalograms from 10 patients, taken at the beginning and on average 2 months after an overbite of 1 to 2 mm was obtained.

5.4. Cephalometric Method

Two lateral cephalometric X-ray films were taken for each patient. The films were taken in Marmara University, Faculty of Dentistry, Oral Diagnosis and Radiology Department. Siemens Orthopas Cephalostat was used. Films were "Kodak X-omat K100" and the size was 18-24 cm. The films were developed using "Okamoto Medical X-Ray film automatic processor". Tracing of the pretreatment and posttreatment cephalograms were done on 8-10" Acetate paper using 0.5 mm tracing pen. To minimize the error of tracing, pairs of cephalograms were traced together at the same sitting. A Cartesian coordinate system was used to measure the positional changes of the cephalometric landmarks between the two tracings. A horizontal reference line (TH) was constructed by reducing 7 degrees from the SN plane. And was used as X-axis. The Y-axis (TV) was constructed by drawing a vertical line passing through the Sella point perpendicular to the X-axis, these constructed lines were mentioned

by Burstone and his colleagues (11) and used in several studies for orthodontic and orthognathic purposes (11,112). The Y and X axis were transferred from the first film to the second film by superimposition along the S-N line. Fifteen cephalometric landmarks were chosen as reference points. Based on these reference points 5 horizontal and 10 vertical planes were constructed. 22 cephalometric measurements were used in the study, 14 linear measurements and 8 angular measurements. Overbite and overjet were also measured from the cephalometric radiographs.

5.4.1. Cephalometric landmarks used in the study (Fig. 5.4)

- 1- Sella (S): geometric center of the pituitary fossa.
- 2- Nasion (N): the most anterior point of the frontonasal suture in the midsagittal plane.
- 3- A point (A): the most posterior midline point in the concavity between the anterior nasal spine and the prosthion(the most inferior point on the alveolar bone overlying the maxillary incisors).
- 4- B point (B): the most posterior midline point in the concavity of mandible between the most superior point on the alveolar bone overlying the lower incisors (infradentale) and pogonion.
- 5- Menton (Me): the lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram.
- 6- Gonion (Go): A point in 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.
- 7- Articulare(Ar): A point at the junction of the posterior border of the ramus and the inferior border of the cranial base(occipital bone).
- 8- Anterior Nasal Spine (ANS): The anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
- 9- Posterior Nasal Spine (PNS): The posterior spine of the palatine bone constituting the hard palate.
- 10-Upper Incisor incisal point (U1): Incisal tip of the upper central incisor.

- 11-Lower Incisor incisal point (L1): Incisal tip of the lower central incisor.
- 12-Upper first premolar cusp point (U4): Cusp tip of the upper first premolar.
- 13-Lower first premolar cusp point (L4): Cusp tip of the lower first premolar.
- 14-Upper First Molar mesial cusp tip (U6): The tip of the mesial cusp of the upper first molar.
- 15-Lower first Molar mesial cusp tip (L6): The tip of the mesial cusp of the lower first molar.

5.4.2. Cephalometric planes

5.4.2.1. Horizontal planes (Fig.5.5)

- 1- Sella-Nasion plane (SN): Horizontal line passing through the Sella and Nasion points.
- 2- Palatal Plane (PP): Horizontal line passing through ANS and PNS points.
- 3- Functional Occlusal plane (FOP): Horizontal line passes through the cusps of posterior teeth.
- 4- Gonion Menton Plane (MP): Horizontal line passing through Go and Me points.
- 5- True Horizontal Plane (TH): Horizontal line made by reducing 7 degrees from the SN plane. (Fig.5.4)

5.4.2.2. Vertical planes

- 1- True Vertical Plane (TV): Vertical line passing through S and perpendicular to TH. (Fig. 5.4)
- 2- Upper Incisor Plane (U1V): Vertical line passing through U1 and upper incisor apical point.
- 3- Upper first premolar plane (U4V): Vertical line passing through U4 and upper premolar apical point.
- 4- Upper first molar plane (U6V): Vertical line passing through U6 and upper first molar apical point.

- 5- Lower first incisor plane (L1V): Vertical line passing through L1 and Lower first incisor apical point.
- 6- Lower first premolar plane (L4V): Vertical line passing through L4 and Lower first premolar apical point.
- 7- Lower first molar plane (L6V): Vertical line passing through L6 and lower first molar apical point.

5.4.3. Linear Measurements

5.4.3.1. Vertical Linear Measurements (Fig. 5.6)

- 1- Upper incisor–True horizontal (U1-TH): Vertical perpendicular distance between U1 point and TH plane.
- 2- Upper first premolar–True horizontal (U4-TH): Vertical perpendicular distance between U4 point and TH plane
- 3- Upper first molar – True horizontal (U6-TH): Vertical perpendicular distance between U6 point and TH plane.
- 4- Anterior facial height (AFH): Vertical distance in mm between the N and Me point.
- 5- Lower facial height (LFH): Vertical distance measured on N-ME plane between Me and a perpendicular line on the N-Me plane from ANS.
- 6- Lower first incisor mandibular plane (L1-MP): Vertical perpendicular distance between L1 and mandibular plane.
- 7- Lower first premolar–Mandibular plane (L4-MP): Vertical perpendicular distance between L4 and mandibular plane.
- 8- Lower first molar–Mandibular plane (L6-MP): Vertical perpendicular distance between L6 and mandibular plane.

5.4.3.2. Horizontal Linear Measurements (Fig.5.6)

- 1- A point-True Vertical (A-TV): Horizontal perpendicular distance between A point and TV.

- 2- B point-True Vertical (B-TV): Horizontal perpendicular distance between B point and TV.
- 3- Upper incisor-True vertical (U1-TV): Horizontal perpendicular distance between U1 point and TV.
- 4- Upper first molar-True vertical (U6-TV): Horizontal perpendicular distance between U6 point and TV.
- 5- Lower incisor-True vertical (L1-TV): Horizontal perpendicular distance between L1 point and TV.
- 6- Lower first molar-True vertical (L6-TV): Horizontal perpendicular distance between L6 point and TV.

5.4.4. Angular Measurements (Fig. 5.7, 5.8)

- 1- Sella Nasion-mandibular plane angle (SN-MP): Angle between SN and mandibular plane.
- 2- Sella Nasion-Palatal Plane angle (SN-PP): Angle between SN and palatal planes.
- 3- Sella Nasion Point A angle (SNA): Angle between SN plane and NA plane.
- 4- Sella Nasion Point B angle (SNB): Angle between SN plane and NA plane.
- 5- A point Nasion B point angle (ANB): Angle between NA and NB plane.
- 6- Gonial angle (Go): Angle between mandibular plane and ArGo planes.
- 7- Sella Nasion – FOP: Angle between Sella Nasion and functional occlusal plane.
- 8- PP – FOP: Angle between palatal plane and functional occlusal plane.

5.5. Overbite and Overjet (Fig. 5.9)

- 1- Overbite (OvB): Vertical distance between 2 lines parallel to the TH plane and touching the incisal tips of the upper and lower incisors (U1 and L1).
- 2- Overjet (OJ): Horizontal distance between 2 lines parallel to the TV plane and passing through the upper and lower incisal edges (U1 and L1).

5.6. Statistical Method

The angular and linear changes related to the maxilla and mandible were analyzed with Wilcoxon signed rank test. SPSS Version 11.0 for MS windows computer package was used on an IBM compatible PC. The mean, median, and standard deviations were calculated for each measurement. The normal distribution of the values was not assumed in this study, but means and standard deviations were used for better presentation techniques and to show all aspects of the variables.

Dahlberg's method was used for the calculation of the operator's random error. 8 cephalograms were selected randomly from the total 20 available, and they were measured twice by the same investigator. The first and second measurements of these films were evaluated according to Dahlberg's formula.

$$S_m = \sqrt{\frac{\sum d^2}{2n}}$$

S_m : The Dahlberg's method error.

d : The difference between two measurements.

n : The number of double measurements.

The error for the angular measurements on the cephalograms did not exceed 0.65°, and for the linear did not exceed 0.36mm.

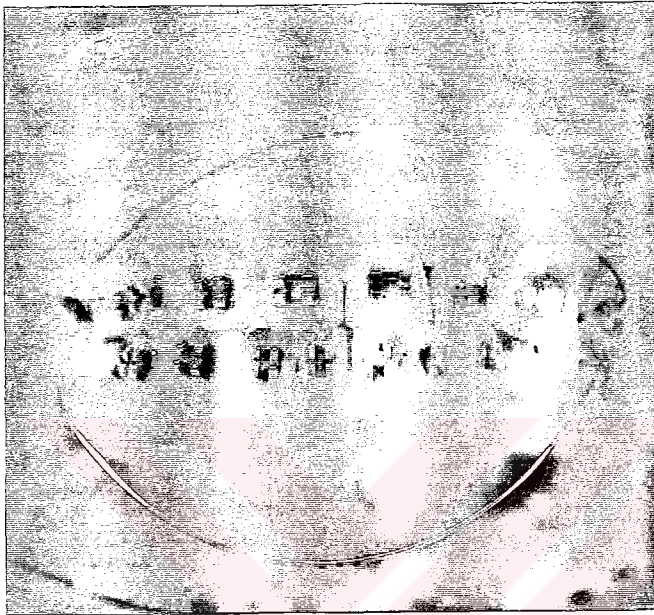


Fig. 5.1 Frontal view of the wires in the active form

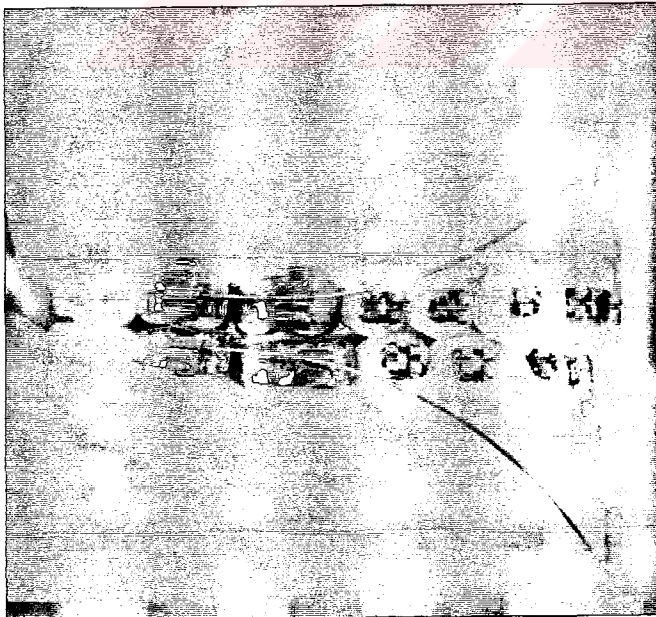


Fig. 5.2 Side view of the wires showing the effect on the anterior teeth

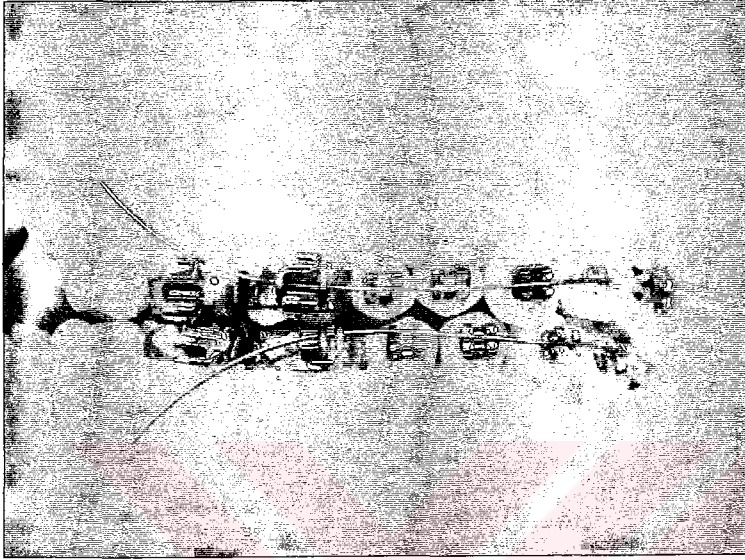


Fig. 5.3 Side view of the wires showing the effect on the posterior segment

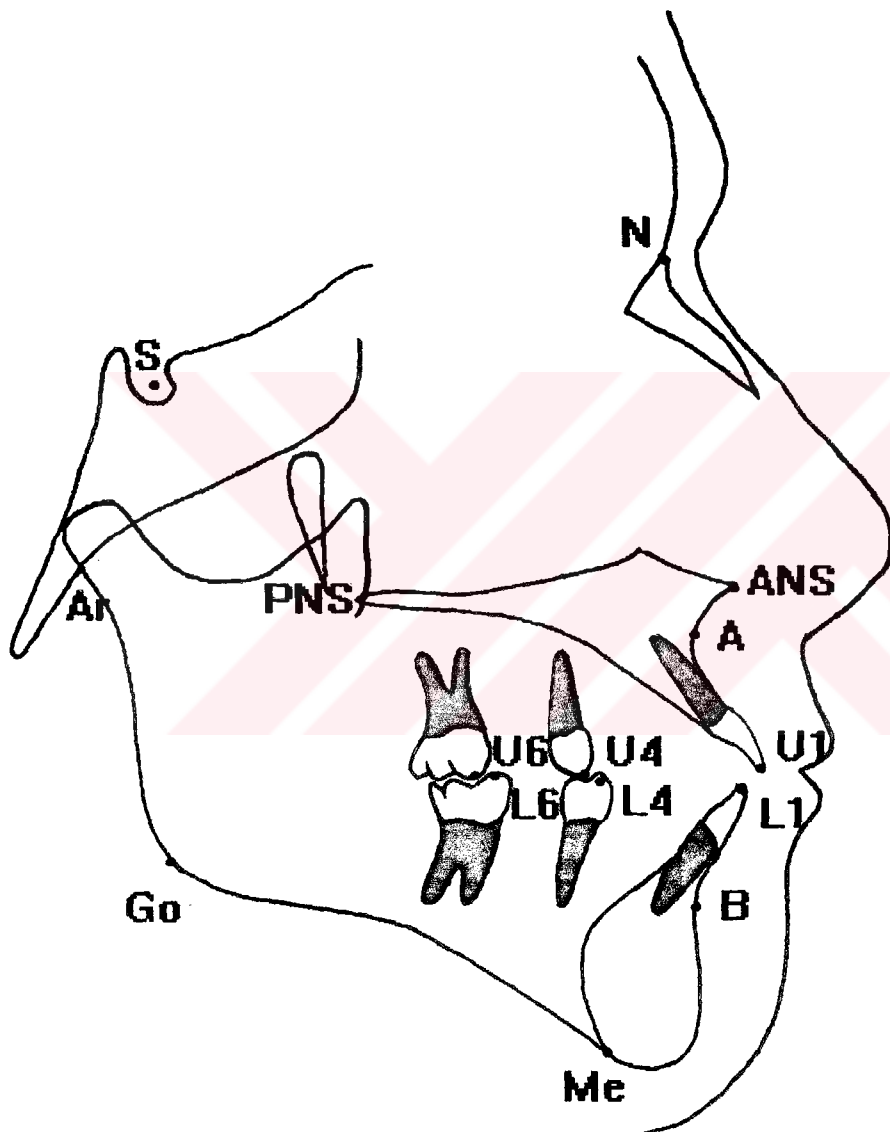


Fig. 5.4 Cephalometric Landmark Points

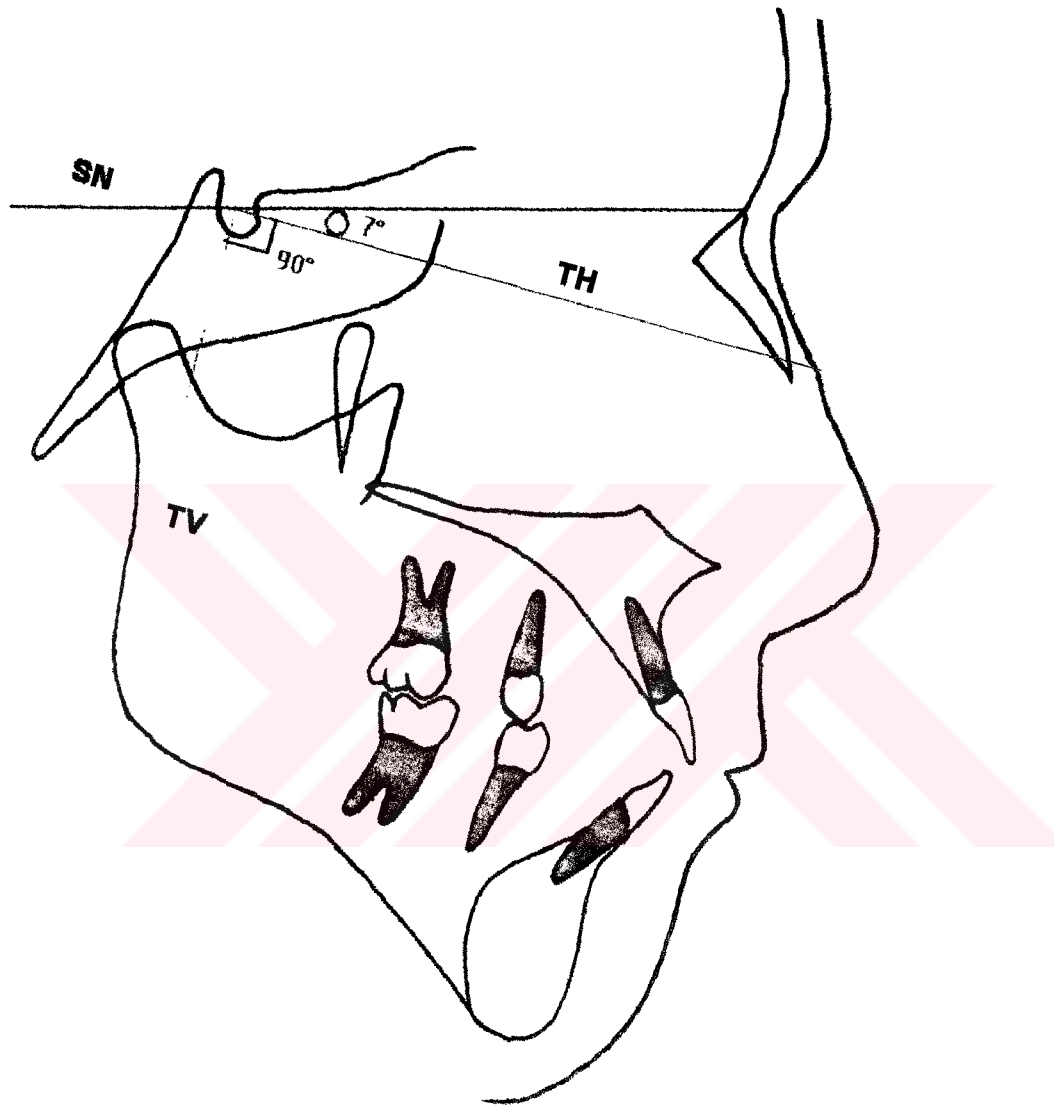


Fig. 5.5 Reference Planes used in the study

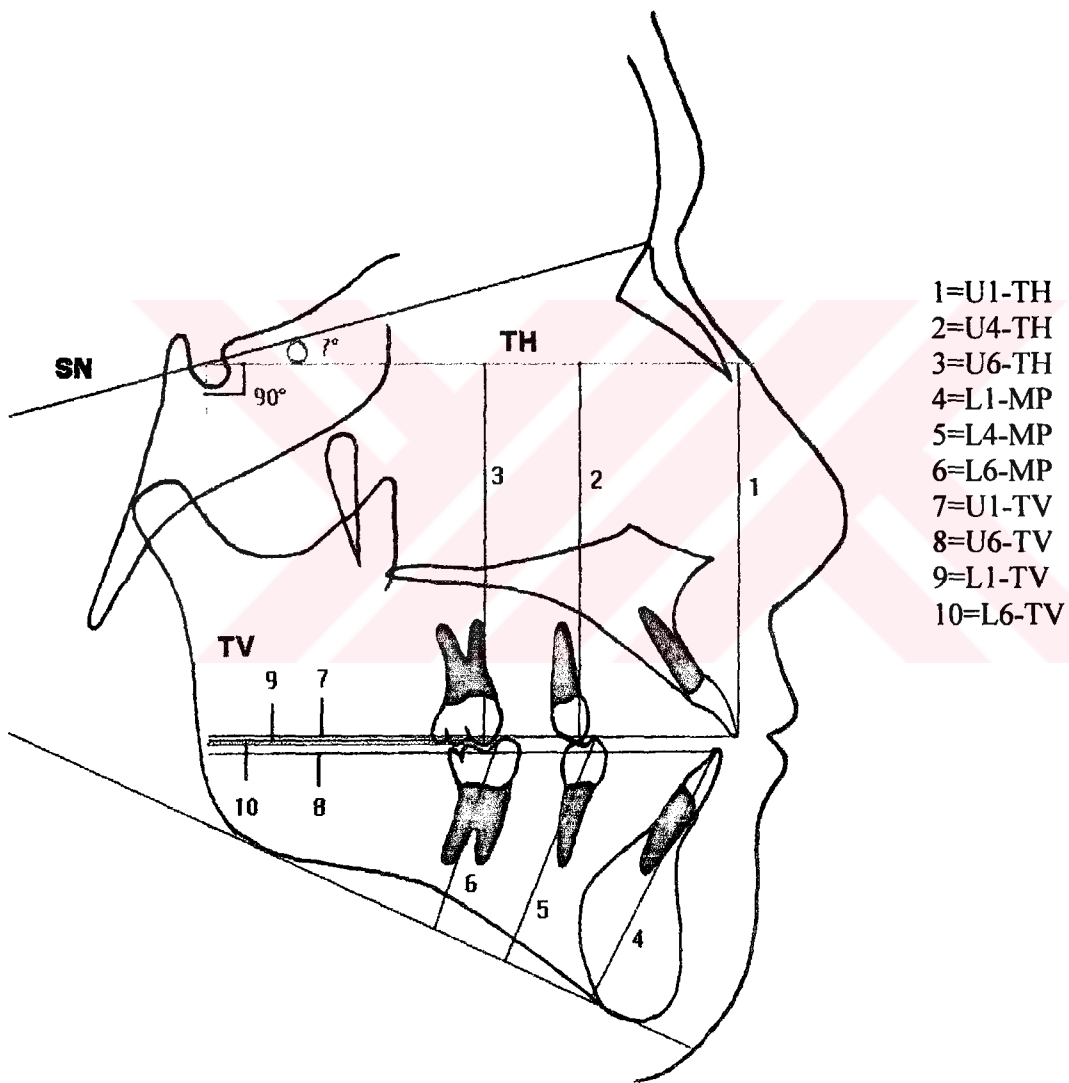


Fig. 5.6 Linear horizontal and vertical dental measurements used in the study

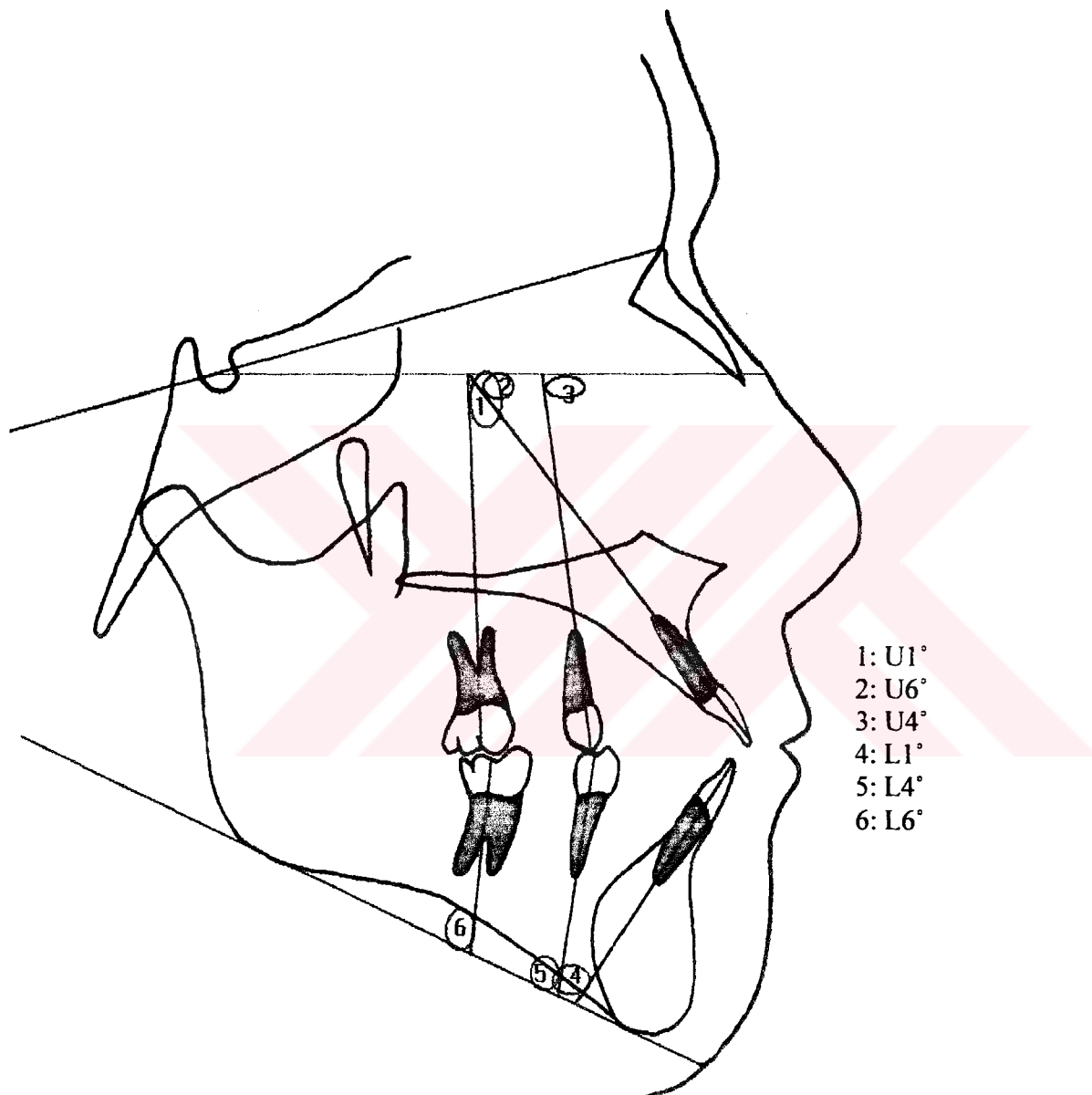


Fig. 5.7 Cephalometric Angular Dental Measurements

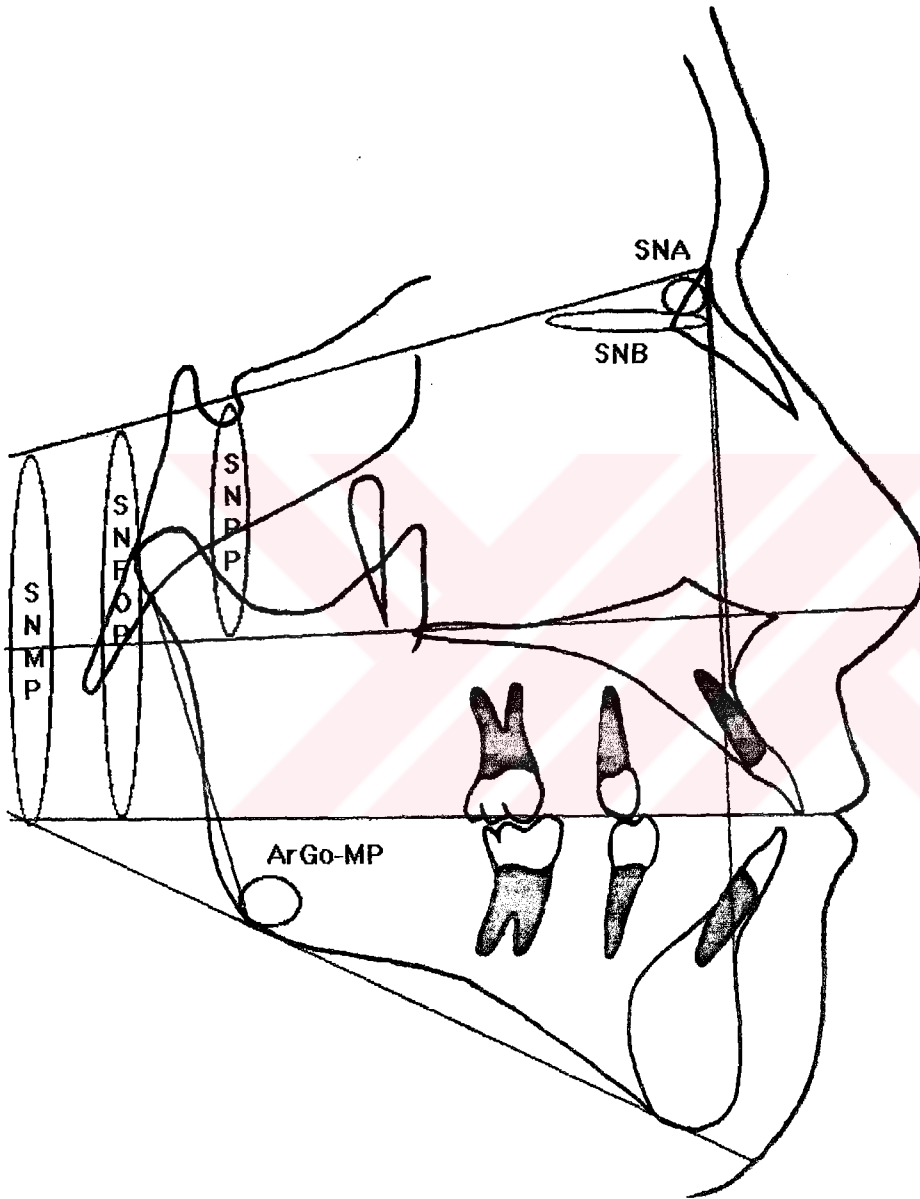


Fig. 5.8 Cephalometric Angular Skeletal measurements

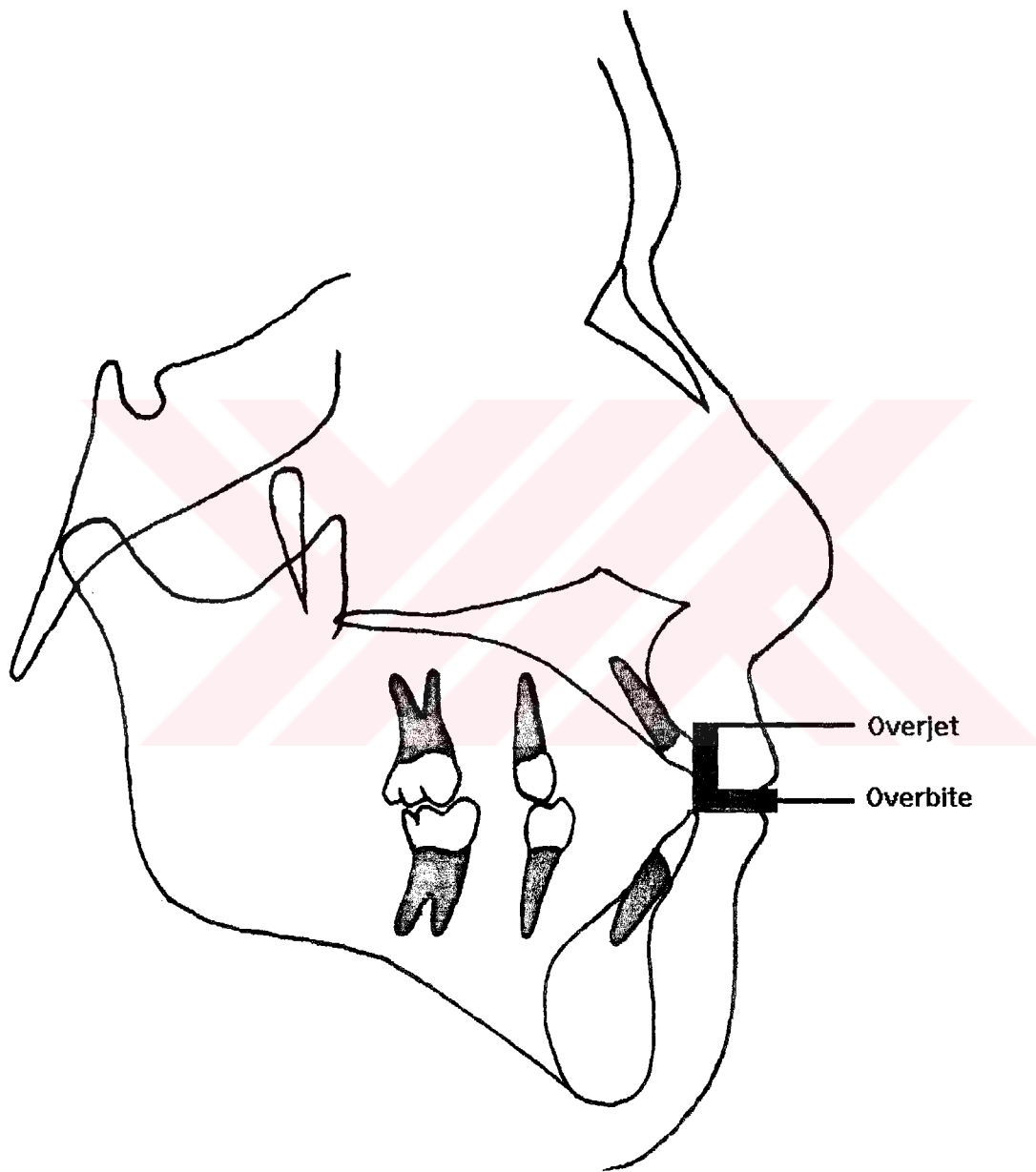


Fig. 5.9 Overbite and Overjet

6. RESULTS

Tables 6.1. and 6.2. show all the results achieved. Mean measurements before and after treatment are written as well as standard deviations. The probability and significance of all these differences are also available in the table.

Changes observed were as follow:

A- Dental changes

- 1- Upper incisors extruded and uprighted significantly.
- 2- Upper first premolars extruded and uprighted significantly.
- 3- Upper first molars uprighted significantly and extruded insignificantly.
- 4- Lower incisors extruded and uprighted significantly.
- 5- Lower first premolars extruded and uprighted significantly.
- 6- Lower first molars uprighted significantly and extruded insignificantly.
- 7- Functional occlusal plane rotated counter clockwise significantly.
- 8- Overbite increased significantly, while overjet decreased significantly.

B- Skeletal changes:

- 1- N-Me increased significantly.
- 2- ANS-Me increased significantly.
- 3- SNA° didn't change and this was considered insignificant.
- 4- SNB° increased insignificantly.
- 5- ANB° reduced insignificantly.
- 6- Gonial angle increased insignificantly.

6.1. Skeletal Changes.

	before		after		difference		wilcoxon P-Value	Sig.
	x	sd	x	sd	x	sd		
SNA	81.78	3.49	81.78	3.31	.00	1.50	1.000	
SNB	78.78	2.95	79.00	3.28	-.22	1.20	.594	
ANB	3.00	3.28	2.78	2.91	.22	1.20	.594	
Go°	130.33	6.93	130.67	7.65	-.33	3.35	.773	
SN-Po	79.67	3.24	79.00	3.81	.67	1.87	.316	
N-ME	120.67	5.20	122.22	5.65	-1.56	1.67	.023	*
ANS-Me	69.44	5.05	71.22	5.72	-1.78	1.48	.007	**

* $p < .05$, ** $p < .01$

6.2. Dental Changes.

	before		after		difference		wilcoxon P-Value	Sig.
	x	sd	x	sd	x	sd		
U1-TH	76.44	18.08	81.33	16.81	4.89	3.48	.003	**
U1-THmm	73.33	4.33	75.33	4.30	2.00	1.41	.003	**
U4-TH	88.89	6.43	96.00	7.70	7.11	7.44	.021	*
U4-THmm	70.33	5.07	71.67	4.47	1.33	1.23	.011	*
U6-TH	99.11	12.82	111.56	7.54	12.44	8.82	.003	**
U6-THmm	68.56	3.32	68.89	3.06	0.33	1.32	.471	
L1-MP	91.33	5.48	86.78	3.49	4.56	3.21	.003	**
L1-MPmm	40.00	3.20	43.00	3.71	3.00	1.41	.000	***
L4-MP	81.11	8.39	69.89	6.27	11.22	9.32	.007	**
L4-MPmm	36.78	2.73	38.33	3.39	1.56	1.24	.005	**
L6-MP	76.89	5.71	66.56	7.54	10.33	6.91	.002	**
L6-MPmm	68.56	3.32	68.89	3.06	0.33	1.32	.471	
SN-FOP	22.44	5.15	18.33	6.42	4.11	3.98	.015	*
PP-FOP	11.44	4.48	7.33	6.29	4.11	3.92	.014	**
Overbite	-2.33	1.32	1.56	.53	-3.89	1.69	.000	****
Overjet	2.44	0.73	1.56	0.89	.56	0.78	.009	**

* $p < .05$, ** $p < .01$, *** $p < .001$

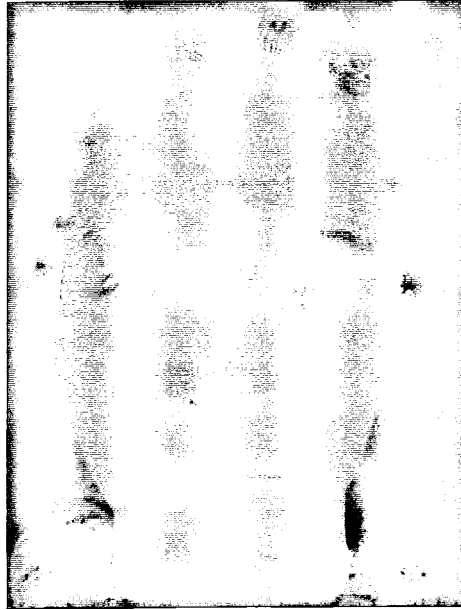


Fig.6.1 Extra Oral Frontal View (Before Treatment)



Fig. 6.2 Extra Oral Frontal View (After Treatment)

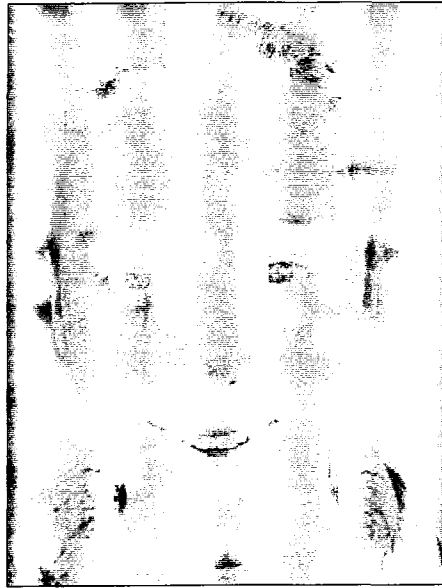


Fig. 6.3 Extra Oral Smiling View (Before Treatment)

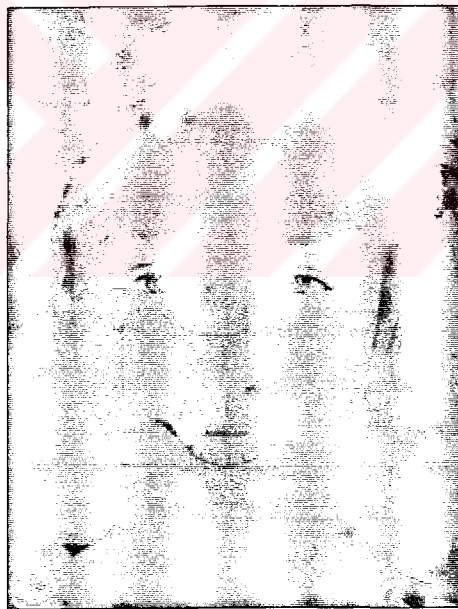


Fig. 6.4 Extra Oral Smiling View (After Treatment)



Fig. 6.5 Extra Oral Profile View (Before Treatment)



Fig.6.6 Extra Oral Profile View (After Treatment)

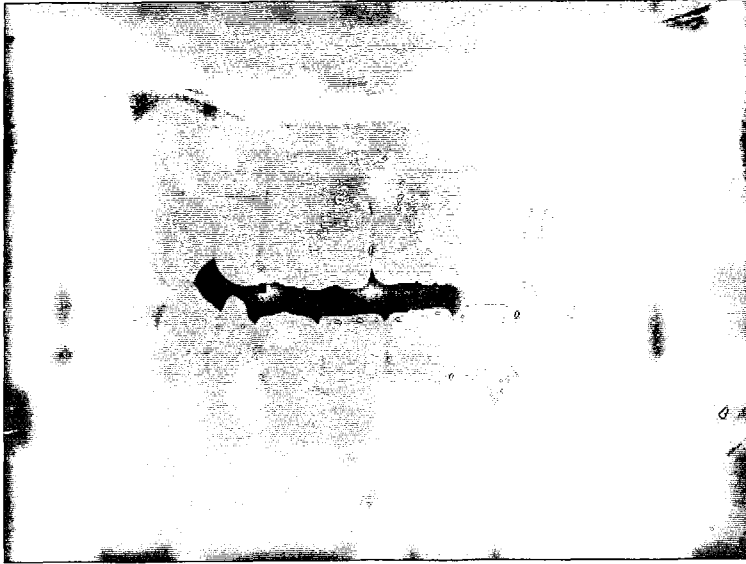


Fig. 6.7 Intra Oral Frontal View (Before Treatment)



Fig. 6.8 Intra Oral Frontal View (After Treatment)

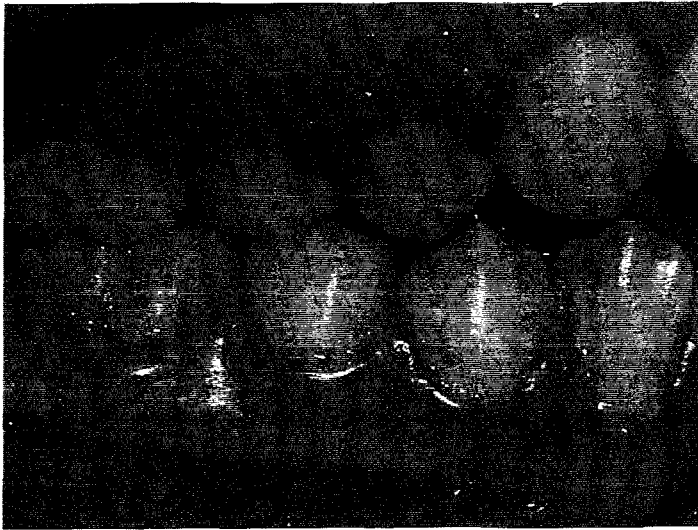


Fig. 6.9 Intra Oral Right Side View (Before Treatment)

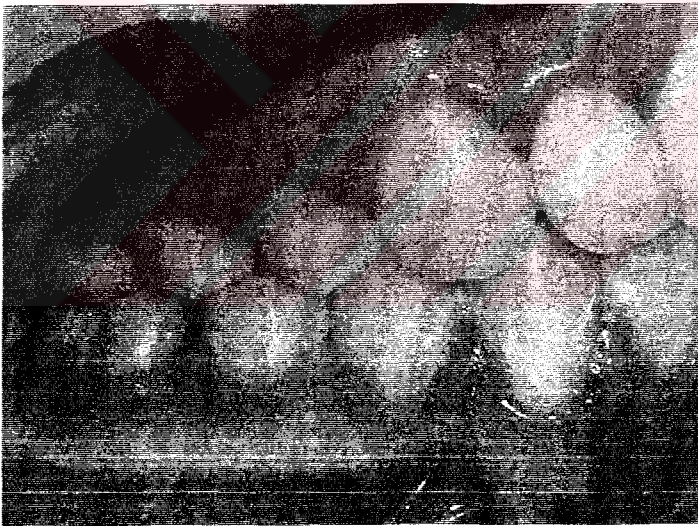


Fig. 6.10 Intra Oral Right Side View (After Treatment)

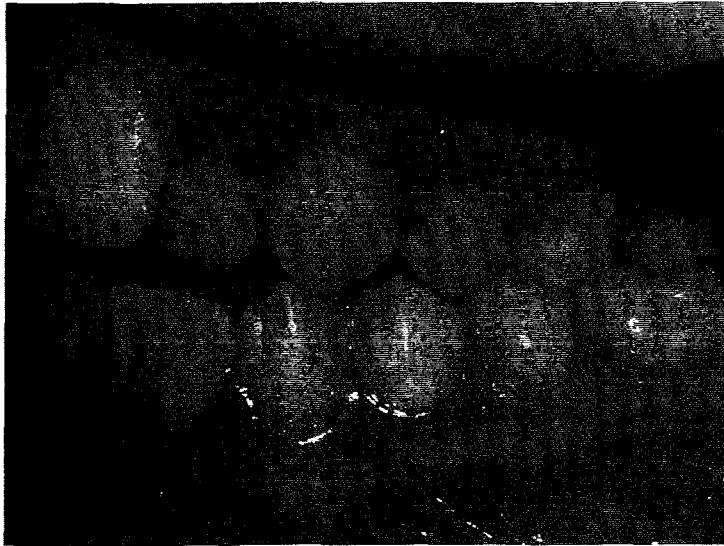


Fig. 6.11 Intra Oral Left Side View (Before Treatment)

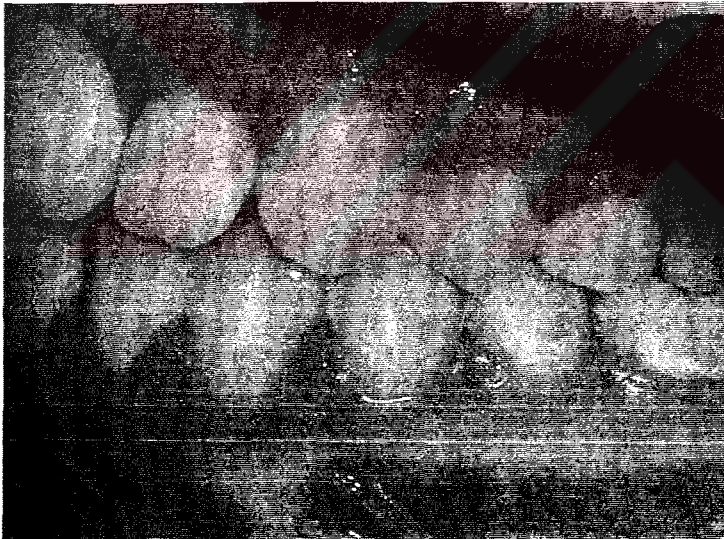


Fig. 6.12 Intra Oral Left Side View (After Treatment)

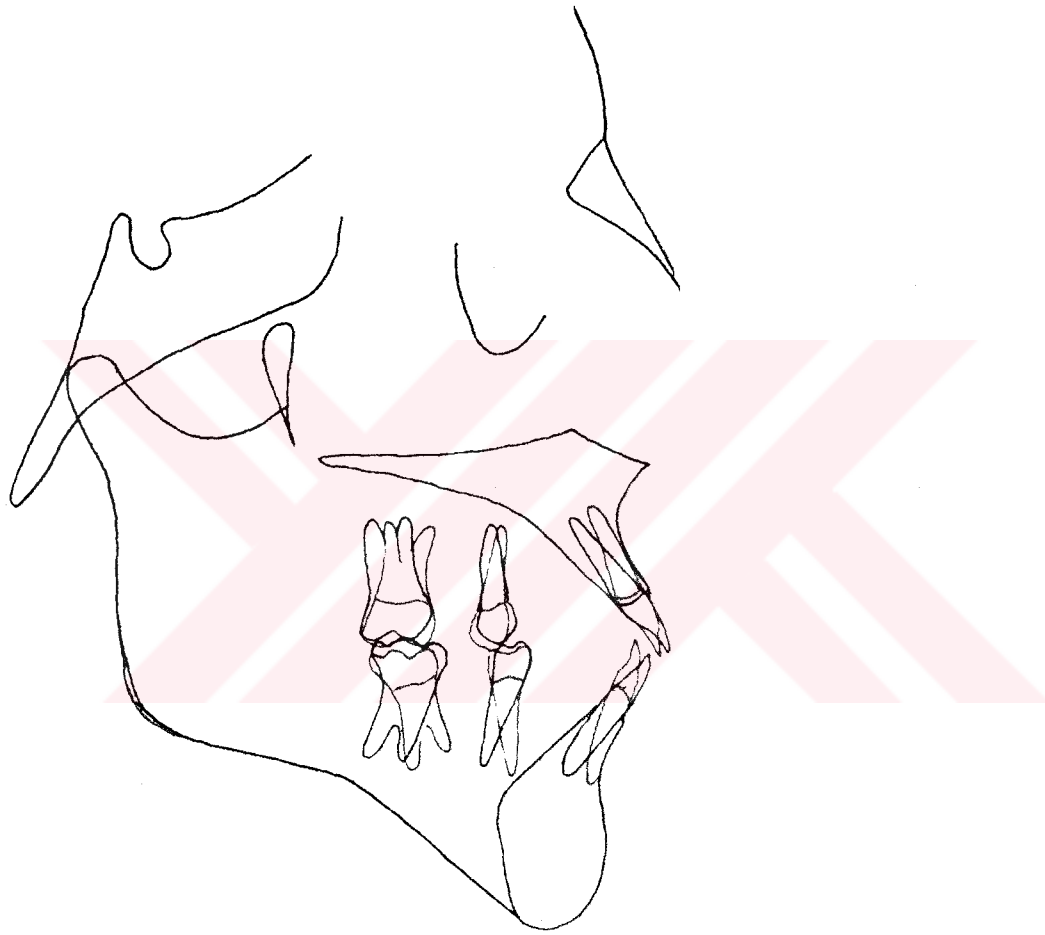


Fig. 6.11 Dental Superimposition after the treatment.
Red: After treatment .

7. DISCUSSION

Open bite is one of the difficult malocclusions to treat and maintain the treatment results. In the morphology of open bite maxillary posterior excess and backward rotation of the mandible are the most important problems. True treatment of the situation aims to intrude the maxillary posterior dentition, achieve mandibular counter clock wise rotation and close the bite.

Several techniques were developed to achieve this aim but today it is known that orthognathic surgery is the only treatment modality to have this result.

Inspired by Kim's technique for open bite closure, Enacar et al (21), designed a treatment modality which included the use of upper accentuated curve and lower reverse curve Ni Ti arches. The philosophy of these arches is to perform intrusive force to both anterior and posterior dentoalveolar segments in the maxilla and mandible. The vertical intercanine elastics are applied to balance the anterior intrusive force of the arches. While the anterior intrusive force is balanced, the posterior intrusive force will be active in intruding the posteriors. This intrusive force will be active in intruding the posterior dentoalveolar segments in both maxilla and mandible, so the anterior rotation of the mandible and closure of open bite will take place.

In the previous studies with these arches, adult patients were used and open bite was closed by more incisor extrusion rather than molar intrusion (13, 21, 31, 62,112).

In this study our aim was to evaluate the effects of these arches in a younger age group, and to see whether it was possible to achieve molar intrusion rather than incisor extrusion at younger ages.

Our study group consisted of 10 cases. This can be accepted as the minimum number necessary for statistical evaluation. As we were using some special criteria to standardize the data, it was not so easy to find more cases.

Karkhaus (60) reported open bite percentage in 14 year old children to be 2.5%. While Tulley (114) studied 1500 eleven year old children, and found that less than 1% had open bite. From this quick observation we can notice that the percentage of open bite cases is very minimal in the population. And in our study we had further more criteria such as Class I molar relationship and no crowding, so it was difficult to have more patients.

Another point was the cooperation of the patients, as our study was highly patient dependent. This also limited our sample as it is not easy to find highly cooperative patients in our age group due to the physiological and psychological changes observed during this stage of their life.

Concerning the statistics, as we had a limited number of cases in our study group, and our group was less than 35 subjects, non parametric statistics were used for the evaluation of the data.

The uprighting and relative extrusion of the upper incisors during treatment could increase the maxillary gingival display of the patients when smiling. Thus, it is of utmost importance to exclude those individuals who already show a "gummy smile" at the beginning of the treatment.

We did not have a control group for two reasons. One of them was the difficulty in obtaining patients within the criteria we selected. As we mentioned previously, the incidence of anterior open bite is rare, adding this to our criteria made it very difficult to find sufficient number of study group patients. The same applies for the control group.

Secondly, we didn't have a control group for ethical reasons. We believe that immediate treatment should be applied for such patients.

We accepted patients in permanent dentition; the maximum age limit was 14 years, as our aim in this study was to treat anterior open bite cases in a younger age group.

We accepted patients in Class I molar relationship, or mild Class II molar relationship, and excluded patients with severe Class II, and Class III relationships as these patients would need another modality in the treatment

process, and by that we standardized the sagittal relationship, and all the patients received the same treatment mechanics.

We treated all cases without extraction, so we excluded patients with severe crowding, as such patients would need extraction, which would affect the standardization process.

It is well known that if the patient does not use the elastics continuously, bite will open more due to the intrusive effect of the wires on the anterior teeth.

At the first appointment it was well explained to the patient and their parents the importance of cooperation in this treatment modality, as this was the key point in the success of such treatment.

As it is well known, approximately six hours after the insertion of the arches and the elastics, a mass movement of the dentition will begin, and the patient will start to experience tenderness of the teeth. The tenderness increases in intensity for about eighteen hours, and diminishes thereafter. If the elastics are worn continuously as instructed, the tenderness does not return, but if the patient wears them intermittently, the tenderness can continue indefinitely (57).

Therefore, we explained to the patient this point as comfort and cooperation of the patient is the main success factor.

First step in our treatment involved leveling, and after that we inserted the curved arches and applied the elastics only in the canine region, the aim was to close the bite at the canine region at the beginning. After 2 months we applied the elastics in a box shape, for 3 months, until the incisal overlap was achieved. Then we applied 0.017-0.022 inch stainless steel wires and continued the use of elastics for another 3 months. The aim was to keep the incisors in the place they extruded to, from a retention point of view.

In general the objective of treatment for an anterior open bite malocclusion should be the creation of an overlapping relationship. The position of the maxillary central incisors relative to the lip line must be at or near the 4mm norm as measured cephalometrically. The maxillary central incisor edges, therefore, should be the guide for the anterior limit of the upper occlusal plane.

The lower occlusal plane should then follow the upper so that there is a sufficient overlap between the maxillary and mandibular incisors. However, because the vertical level of the occlusal plane in the posterior segment is determined by the physiology, anatomy, and function of the surrounding structures, it cannot be altered readily.

In order to accomplish correction of a malocclusion, the dentition must be placed in a proper three-dimensional perspective; anteroposteriorly, vertically, and bilaterally. Anteroposteriorly, the axial inclinations of all teeth must be correct. Vertically, the level of each crown relative to the adjacent teeth as well as to the opposing teeth must be correct. Last, but not least, the width of the arches and torque of the posterior teeth must be correct for successful interdigitation.

To stress the importance of posterior axial inclination which we aimed to correct in our study, we refer to Tweed who taught the concept of anchorage preparation by uprighting the posterior teeth, especially those of the mandible (115).

Unfortunately, the concerns for appropriate axial inclinations of the teeth have been generally limited to the incisors. Whatever the reason may be, the inclination of posterior teeth has been unimportant in the eyes of many orthodontists, and is not usually incorporated into the diagnosis of a malocclusion (57).

In any malocclusion, the axial inclination of each component of the entire dentition is important. Especially in open bite cases, the inclination is characteristically mesial. The greater the openness of the occlusal planes, the greater the inclination of the dentitions to the bisected occlusal plane.

The reasons for variations in axial inclination can be many. Tooth formation and eruption path are presumed to be genetically predetermined. During the mixed dentition period, local factors may divert the eruption of a tooth into an altered inclination (57). A strong anterior component of force or a crowded dentition in a small arch could well account for excessive mesial inclination of some teeth.

In treating an open bite, the cant of individual occlusal planes must be corrected and the teeth must be uprighted in relation to the bisecting occlusal plane for ensuing stability and function. And this is what we are seeking here.

In cases of marked open bite, especially those with a steep mandibular plane and/or palatal plane along with a relatively short posterior vertical dimension, the last molars in the mouth are the only teeth that can occlude. Molars are markedly inclined mesially, and their occlusal contact blocks further closure. The objective of open bite treatment, therefore, is to eliminate the blocks and upright the inclined molars.

According to Kim et al (57) if the patient is still parapubertal, and if the third molars are developing normally, the second molars may be extracted to eliminate the blocking effect. The first molars can then be uprighted distally to produce a change in the individual occlusal plane. In carefully selected situations, the third molars erupt satisfactorily to take the place of the second molars. In older patients and those with poor third molar prognosis, the third molars should be removed and the other molars then uprighted.

Extraction of second or third molars not only eliminates the dynamic blocking effect; it also eliminates much of the cortical bone that resists the uprighting of the molar mesial to it. Such extractions also eliminate posterior crowding, which is commonly present in open bite, and initiate tissue rebuilding in the extraction site distal to the last molar which is to be uprighted.

With the new space created, and the immature tissues immediately distal to the mesially inclined molar, the distal tipping is readily accomplished.

On the other hand, attempting the same distal tipping procedure without extraction would encounter great resistance. The reciprocal forces generated in such attempts invariably cause mesial tipping of the anterior teeth. The anterior component when the jaw closes on the blocking molars combines with the posterior crowding to generate a total anterior component of force which makes a distal movement or tipping of such molars impossible.

In our study we did not perform any extractions, as the crowding value was not significant to indicate any extractions, but we were forced at the end of

the treatment to band the lower second molars, in order to correct their axial inclination too. In our study the upper and lower third molars were not erupted in all our cases due to the age of the patients. We did not have any significant space shortage in any of our cases. Even in two cases the third molars were congenitally missing. These could be considered further reasons for adapting the non extraction therapy in our study.

The results of our study indicated that bite closure had been achieved to a great extent by uprighting and extrusion of the lower incisor and upper incisors. Elastics, which were applied to prevent incisor intrusion as a result of NiTi arch wires, caused extrusion and uprighting of the incisors. The 2.00 mm extrusion ($P<0.01$) measured in the upper incisors was in part due to the change in the relative distance of the incisor tip to the true horizontal plane "TH" that took place as the central incisor was being uprighted (5.38°) and this was also significant ($P<0.01$). In a previous study done in our department, Kucukkeles et al (62) found that the extrusion in the upper incisors was 3.07 mm and the uprighting was 6.41° , and both results achieved were found significant too.

In a study conducted by Chang et al in Seoul University (13), the aim was to evaluate the treatment changes of anterior open bite malocclusion cases treated by means of the Multiloop Edgewise Arch Wire technique. In that study they found that the upper incisors extruded significantly by 1.92 mm. ($P<0.001$).

To discuss in details the lower incisors changes, we found that they were both extruded and uprighted. The lower incisors extruded 3 mm ($P<0.001$) while in the previous study which was conducted on adults, lower incisors extruded 3.35 mm (62). Lower incisors were also uprighted 3.38° ($P<0.01$) while they were uprighted 1.26° in the previous study.

In Chang's study (13) they were extruded 2.78 mm ($P<0.001$).

Proffit (81) pointed out that when an anterior open bite can be treated by elongating the incisors, it is better for both esthetics and stability to elongate the

lower incisors, not the upper incisors. And as we notice in all the previous studies more lower incisor extrusion was achieved.

If we compare the effect on upper premolars among the studies we can find that in our study upper first premolars extruded 1.33 mm ($P < 0.01$) while in the last study (62) conducted in our department they extruded 0.7 mm.

Concerning the lower first premolars they extruded 1.56 mm ($P < 0.01$) while in the previous study they extruded 2.59 mm (62).

Although the configuration of the arch wires in the molar region forced the molars to be both intruded and uprighted, no molar intrusion took place. Instead, the molars were uprighted and slightly extruded. Extrusion of molars is an undesirable treatment effect in the group of patients that formed our study sample. However, the amount of lower molar extrusion in the present study was minimal (0.33 mm), and it may have been related to the selection of mesiobuccal cusp tip of the first molar as a landmark for linear measurements. In the previous study it was found that the lower molar extruded by 1.38 mm (62). Mesiobuccal cusps of both upper and lower first molars are expected to be elevated as a result of the uprighting movement caused by the upper accentuated-curve and lower reverse-curve arch wires.

1.04 mm lower molar extrusion occurred in the Chang study but this was not considered significant statistically. (13).

Lower first molar were uprighted significantly in our study by 10.33° .

If we compare the effect of such treatment technique on the upper molars we can notice that 1.11 mm ($P < 0.01$) extrusion occurred in Kucukkeles et al (62) study. While 1.41 mm non significant extrusion happened in Chang et al study (13). In our study upper molars extruded insignificantly 0.33 mm, but they were uprighted significantly by 12.44° , ($P < 0.01$). We can simply say that only uprighting effect occurred in the upper molars.

Extrusion of lower premolars and uprighting of lower molars have led to rotation of the functional occlusal plane in a counterclockwise direction, thus decreasing its steepness. The increase in N-Me and ANS-Me could be attributed to this 0.33 mm extrusion of lower first molars, and 0.33 mm in the upper molars

which may have caused very slight clockwise rotation of the mandible. However, this change was not reflected in mandibular plane angle, which stayed stable throughout treatment.

Extrusion of lower incisors, increase in overbite, and uprighting of upper incisors were in accordance with the findings of Goto et al (31), Enacar et al (21), Kucukkeles et al (62) and Chang et al (13). Furthermore, uprighting of teeth in the buccal segments and the alteration of the occlusal plane to SN angle were in agreement with the reports of Enacar et al. On the other hand, Goto et al reported an increase in SNB angle and a decrease in ANB and mandibular plane angles, while in the present study no significant difference was noted regarding these parameters.

The effects of this treatment method were similar to those of the multiloop edgewise arch wire system in that the inclination of the occlusal plane was corrected, open bite was corrected by extrusion and uprighting of both upper and lower incisors, and axial inclinations of the posterior teeth were uprighted. Working with upper accentuated-curve and lower reverse-curve NiTi arch wires was less time consuming compared with multiloop arch wires. The patients did not have any difficulty in maintaining their oral hygiene, and there was no complaint about oral soft tissue irritations.

As we didn't have a control group we refer to Chang et al (13), they reported upper and lower molar extrusion in a control group consisting of 17 growing patients with a mean age of 13.50 years. Upper molars extruded 0.72 mm while lower molar extruded 3.45 mm in their study.

In our study no molar intrusion was achieved, but we were able at least to hold the molars in their place and to prevent an increase in the vertical dimension.

In the orthodontic literature we can find some studies in which open bite was corrected by molar intrusion.

The use of active vertical corrector appliance was studied in a research by Barbe and Sinclair (4). They reported treatment of open bite cases mainly due to molar intrusion and partially due to incisor extrusion and retroclination. The amount of intrusion that they reported was 0.6 mm in upper molars and 0.4 mm in lower molars.

Karla et al (58) used a fixed magnetic appliance on ten patients 8-10 years old. 4 months of treatment was done and they reported an intrusion in all of the maxillary and mandibular teeth of about 1.5 mm. They also reported a forward upward rotation of the mandible, but they also mentioned that a small rebound of the intruded teeth happened after treatment. In a study to compare that effects of magnetic and spring loaded bite plates (91), the spring loaded appliances were found not to cause any molar intrusion.

Umemori et al (116) advocated the use of implants. They presented 2 anterior open bite cases treated by intrusion of the lower molars with the help of mini implants in the mandible and elastic modules. They reported 3-5 mm of intrusion in the lower molars. Another thing reported was that the lower and upper incisors were extruded about 2 mm each.

Erverdi et al (23) reported 3 mm intrusion in the upper molars using the implants in the zygomatic region.

Stability of treatment effects is probably the most important criterion when deciding on a treatment method for open bite correction. Posterior mandibular rotation resulting from growth after treatment (76) or extrusion of posterior teeth during treatment (89) has been reported as an important factor for open bite relapse. In a study conducted by Kucukkeles et al (62) cephalometric evaluation of 17 patients at the end of 1 year postretention has shown that although upper and lower incisor positions and the inclination of functional occlusal plane had been maintained, there was a decrease in overbite that was due to extrusion of

upper and lower first molars. Total anterior and lower anterior face heights were increased, again as a result of upper and lower molar extrusion.

Relapse into anterior open bite can occur by depression of the incisors and/or elongation of the molars. In patients without a habit of placing an object between their front teeth, open bite relapse is usually the result of elongation of the posterior teeth, with no apparent intrusion of incisors (81) Vertical growth and eruption of posterior teeth may continue until late teen years or early twenties, making the open bite tendency quite difficult to control. Thus, retention in open bite patients should be long term and involve strict control of eruption of the posterior teeth.

As a conclusion this technique was effective in the treatment of open bite in young adolescents. Further studies are suggested to investigate the long term stability of our results.

8. CONCLUSION

The conclusions of this study were as follows:

1. The treatment changes mainly occurred in the dentoalveolar region.
2. The upper accentuated and lower reverse curve therapy was shown to be an effective and efficient method to treat open bite malocclusion. As a result of treatment, the overbite increased an average of 3.89 mm in young adolescents.
3. The treatment changes were an alteration of the functional occlusal plane in a counter clock wise direction accompanied by the uprighting of the posterior teeth.
4. Both upper and lower incisors were uprighted and extruded in our study.
5. No molar intrusion was achieved, both upper and lower molars slightly extruded and uprighted. These were in accordance with the previous findings conducted on adults.

9. REFERENCES

1. Arat M., Iseri H.: Orthodontics and Orthopedic approach in the treatment of skeletal open bite. *Eur J Orthod.*, 207-215, 1992.
2. Arvastas MG.: Treatment of anterior skeletal open bite deformity. *Am J Orthod.*, 72:147-64, 1977.
3. Atkinson SR.: Open bite malocclusions. *Am J Orthod.*, 52:877-86, 1966.
4. Barbe R.E., Sinclair P.M.: A cephalometric evaluation of anterior open bite correction with magnetic active vertical corrector . *Angle Orthod.*, 61:93-100, 1991.
5. Baumrind S., Molther R., West E., Miller D.: Mandibular plane changes during maxillary retraction. *Am J Orthod.*, 74:603-20, 1978.
6. Bell WH.: Correction of skeletal type of anterior open-bite. *J Oral Surg.*, 29:706-14, 1971.
7. Bilin S.: The nature of arch width difference and palatal depth of the anterior open bite. *Am J Othod.* 113:344,50, 1998.
8. Bjork A., Skyiller V.: Facial development and tooth eruption, an implant study at the age of puberty. *Am J Orthod.*, 62:339-83, 1972.
9. Bjork A.: Prediction of mandibular growth rotation. *Am J Orthod.*, 55:585-598, 1969.
10. Brunelle JA., Profit WR.: The characteristics of malocclusion: A modern approach for classification and diagnosis, *Am J Orthod.*, 56:443-454, 1969.
11. Burstone C J., James RB., Legan H., Murphy GA., Norton LA.: Cephalometrics for orthognathic surgery. *J Oral Surg.*, 36:269, 1978.
12. Cangialosi T.: Skeletal morphologic features of anterior open bite. *Am J Orthod.*, 85:28-36, 1984.
13. Chang Y.: Cephalometric evaluation of the anterior open bite treatment. *Am J Orthod.*, 115:29-38, 1999.

14. Cooke MS, Newsome PR.: Combined orthodontic and restorative correction of severe anterior open-bite. *Quint Intern.*, 21:729-36, 1990.
15. Dellinger EL.: A clinical assessment of the active vertical corrector, a nonsurgical alternative for skeletal open bite. *Am J Orthod.*, 89:428-36, 1986.
16. Dellinger E , Dellinger E . Active vertical corrector treatment. Long term follow up of anterior open bite treated by intrusion of posterior teeth. *Am J Orthod.*, 110:145-154, 1996.
17. Denison T., Kokich V., Shapiro P.: Stability of maxillary surgery in open bite versus non open bite malocclusions. *Angle Orthod.*, 59:5-10, 1989.
18. Dung D.J., Smith R.J.: Cephalometric and clinical diagnosis of open bite tendency. *Am J Orthod.*, 98:484-490, 1988.
19. Eliakim Mirzahi.: Positive intermaxillary pressure appliance. *J clinical Orthod*, 19:579-582, 1985.
20. Ellis E., McNamara JR., Lawrence TM.: Components of adult Class II open bite malocclusion. *J Oral Maxillofac Surg.* 43:92-105, 1985.
21. Enacar A., Ugur T., Toroglu S.: A method for correction of open bite. *J Clin Orthod.*, 30:43-8, 1996.
22. Erbay E. Ugur T. Ulgen M.: The effects of Frankels functional regulator (FR-4) therapy on the treatment of Angle class I skeletal anterior open bite mal occlusion. *Am J Orhod.*,108:9-21, 1995.
23. Erverdi N., Tosun T., Keles A.: A new anchorage site for the treatment of anterior open bite: zygomatic anchorage. A case report. *World J Orthod.*, 3:147-153, 2002.
24. Fletcher SG.: Tongue thrust swallow, speech articulation, and age. *J Speech Hear Disord.*, 26: 201, 1961.
25. Frankel R, Frankel C.: A functional approach to treatment of skeletal open bite. *Am J Orthod.*, 83:54-68, 1983.
26. Frost DE., Fonseca RJ., Turvey TA., Hall DJ.: Cephalometric diagnosis and surgical orthodontic correction of apertognathia. *Am J Orthod.*, 73: 657-669, 1980.

27. Galletto L.: Adult anterior open bite. *Am J Orthod.*, 6:522-526, 1990.
28. Generson RM., Porter JM., Zell A., Stratigos GT: Combined surgical and orthodontic management of anterior open-bite using corticotomy. *J Oral Surg.*,36:216-9, 1978.
29. Gershater MM.: The proper prospective of open bite. *Angle Orthod.*, 42:263-72, 1972.
30. Glenn G.: An American Board of Orthodontics case report: The orthodontic surgical correction of a class II malocclusion with anterior open bite. *Am J Orthod.*, 110:81-7, 1996.
31. Goto S., Boyd RL., Nielsen IL., Iizuka T.: Case report: nonsurgical treatment of an adult with severe anterior open bite. *Angle Orthod.*, 64:311-8, 1994.
32. Graber M, Vanarsdall R. *Orthodontics: Current principles and techniques.* Mosbey year book 1994. 2nd edition.
33. Graber T. M.: *Orthodontics, principles and practice.* 2nd Edition. 468–470, Saunders, Philadelphia. 1966.
34. Graber TM.: Lecture. Biennial meeting of Edward A. Angle Society. Denver, Colorado: 1969.
35. Hapak FN: Cephalometric appraisal of the open bite case. *Angle orthod.*, 34: 65-72, 1964.
36. Harvold E. , Chierici G., Vargervik K.: Experiments on the development of dental malocclusions. *Am.J. Orthod.*, 61:38-44, 1972.
37. Harvold E. P., Chierici G., Vargervik K.: Primate experiments on oral sensation and dental malocclusions. *Am. J. Orthod.*, 63:494-508, 1973.
38. Hayward JR.: Surgical correction of anterior open bite. *Int J Oral Surg.*, 7:286-8, 1978.
39. Heckmann U.: The treatment of anterior open-bite with removable appliances. *Trans Eur Orthod Soc.*, 00:173-80, 1974.
40. Hellman M: Open bite. *INT J ORTHOD*, 17: 421, 1931.
41. Hernandez-Orsini R.: Class I open bite: a case report. *Am J Orthod. Dentofac Orthop.*, 99:100-6, 1991.

42. Horowitz S., Hixon E. H.: The nature of orthodontic diagnosis. Mosby, St. Louis., p. 138, 1966.
43. Huang G., Justus R., Kennedy D., Kokich V.: Stability of anterior openbite treated with crib therapy. *Angle Orthod.*, 60:17-24, 1990.
44. Ingervall B.: Facial morphology and activity of temporal and lip muscles during swallowing and chewing. *Angle Orthod.*, 46:372-80, 1976.
45. Isaacson KG.: Overbite and facial height. *Dent Pract.*, 20:398-408, 1970.
46. Isaacson J, Isaacson R, Spiedel M, Worms F.: Extreme variation in vertical facial growth and associated variation in skeletal and dental relations. *Angle Orthod.*, 41:219-229, 1971.
47. Isaacson R, Zapfel R, Spiedel M, Worms F, Bevis R.: Some effects of mandibular growth on the dental occlusion and profile. *Angle Orthod.*, 47:97-106, 1977.
48. Isaacson R., Spiedel M., Worms F.: Tongue thrust therapy and anterior open bite. *Am J Orthod.*, 62:287-95, 1972.
49. Jazmin Oliva de Cuebas.: Non surgical treatment of a skeletal vertical discrepancy with a significant open bite. *Am J Orthod.*, 112:124-31, 1997.
50. Jeryl D.: Early treatment of skeletal open bite malocclusions. *Am J Orthod.*, 121:563-5, 2002.
51. Kassiseh S.A., Collins M.K. , English JD.: Case report : Ortho surgical correction of a class II open bite , with previous first premolar extraction without follow up orthodontic treatment *Am J Orthod.*, 112:589-95, 1997.
52. Katsaros C., Berg R.: A follow-up of orthodontic treatment effects. *Eur J Orthod.*, 15:273-280, 1993.
53. Kelly JE., Sanchez M., Van Kirk LE.: An assessment of the occlusion of the teeth of children aged 6-11 years, united states PHS pub Washington, DC, 74:1612, 1973.
54. Kiliaridis S., Egermark I., Thilander B.: Anterior open bite treatment with magnets: an experiment in nongrowing baboons. *Am J Orthod. Dentofac Orthop.*, 100:393-400, 1991.

55. Kim Y., Han U., Lim D., Serranon M.: Stability of anterior open bite correction with multiloop edgewise arch therapy: A cephalometric follow-up study. *Am J Orthod.*, 118:43-54, 2000.
56. Kim Y. H.: Overbite depth indicator with particular reference to anterior openbite. *Am. J. Orthod.*, 65:586–611, 1974.
57. Kim Y.: Anterior open bite and its treatment with multiloop edgewise archwire. *Angle Orthod.*, 57:290-321, 1987.
58. Klara V, Burstone C., Nanda R.: Effects of a fixed magnetic appliance on the dentofacial complex. *Am J Orthod.*, 95:467-78, 1989.
59. Koharto Yashiro, Kenji Takada: Tongue muscle activity after orthodontic treatment of open bite : a case report. *Am J Orthod.*, 115:6, 1999.
60. Korkhaus G.: The frequency of orthodontic anomalies at various ages. *Int J Orthod.*, 14:120, 1928.
61. Koski K. ,Lahdemaki P. : Adaptation of the mandible in children with adenoids. *Am. J. Orthod.*, 68:660-665, 1975.
62. Kucukeles N, Acar A, Demirkaya A, Evrenol B, Enacar A.: Cephalometric evaluation of open bite treatment with Ni Ti arch wires and anterior elastics. *Am J Orthod.*, 116:555-62, 1999.
63. Kydd W.L.: Tongue and lip forces extended during deglutition of tongue thrusters compared to a sample population of normal swallowers. *J Dent. Res.* 43:363, 1964.
64. Leward C. Fish, Larry M. Wolford, Bruce N. Epker.: Surgical orthodontic correction of vertical maxillary excess. *Am J Orthod.*, 73:241-57, 1978.
65. Linder-Aronson S., Henrikson C.O.: Radiocephalometric Analysis of Anteroposterior Nasopharyngeal Dimensions in 6-to-12-Year-Old Mouth Breathers Compared with Nose Breathers. *Otol., Rhinol., Laryngol.*, 35:19–29.1973.
66. Linder-Aronson S.: Adenoids. Their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the dentition. *Acta. Oto-Laryng.*, Stockholm. Suppl. 265, 1970.

67. Little RM., Wallen RT., Riedel RA.: Stability and relapse of mandibular anterior alignment--first premolar extraction cases treated by traditional edgewise orthodontics. *Am J Orthod.*, 80: 349-365, 1981.
68. Lopez-Gavito G., Wallen TR., Little RM., Joondeph DR.: Anterior open bite malocclusion: a longitudinal 10-year postretention evaluation of orthodontically treated patients. *Am J Orthod.*, 87:175-186, 1985.
69. Michael D., Insoft, Richard A. Hocevar.:The nonsurgical treatment of a Class II open bite malocclusion.*Am J Orthod.*, 110:598-605 , 1996.
70. Miller H.: The early treatment of anterior open bite. *Int J Orthod.*, 7:5-14, 1969.
71. Mizrahi E.: A review of anterior open bite. *Br J Orthod.*, 5:21-7, 1978.
72. Moss ML, Salentijn Letty: Differences between the functional matrices in anterior open bite and deep over bite. *Am J Orthod.*, 60: 264-279, 1971.
73. Nahoum H.I.: Vertical proportion and the palatal plane in anterior open bite. *Am J Orthod.*, 59:273-82, 1971.
74. Nahoum H.I., Horowitz S.L., Benedicto E.A.: Varieties of anterior open bite. *Am J Orthod.*, 61:486-92, 1972.
75. Nahoum H.I.: Anterior open bite: a cephalometric analysis and suggested orthodontic treatment procedures. *Am J Orthod.*, 67:513-521, 1975.
76. Nemeth R.B., Isaacson R.J.: Vertical anterior relapse. *Am J Orthod.*, 65:565-85, 1974.
77. Pae E., Kuhlburg A., Nanda R.: Role of pharyngeal length in patients with a lack of over bite. *Am J Orthod.*, 112:179-86, 1997.
78. Parker J.H.: The interception of the open bite in early growth period. *Angle Orthod.*, 41:24-44, 1971.
79. Proffit W., Bailey L., Phillips C., Turvey T.: Long-term stability of surgical open-bite correction by LeFort I osteotomy. *Angle Orthod.*,70:112-7, 2000.
80. Proffit W.: On the aetiology of malocclusion. *Brit J Orthod.*, 13:1-11, 1985.
81. Proffit W, Fields H. *Contemporary Orthodontics*. Mosby Year Book, second edition 1993.

82. Quinn G. W.: Airway interference and its effect upon the growth and development of the face, jaws, dentition and associated parts. North Carolina Dental Journal, 60:28-31, 1978.
83. Rains M., Nanda R.: Soft tissue changes associated with maxillary incisors retraction. Am J Orthod., 81:481-488, 1982.
84. Raymond E.: A cephalometric evaluation of anterior openbite correction with the magnetic active vertical corrector. Am J Orthod., 2: 93 -102, 1991.
85. Rein B.: Treatment of anterior open-bite malocclusion. Int J Orthod., 7:27-34, 1969.
86. Reitzik M., Barer PG., Wainwright MW., Lim B.: The surgical treatment of skeletal anterior open bite deformities with rigid internal fixation in the mandible. Am J Orthod Dentofac Orthop., 97:52-7, 1990.
87. Richardson AR: Skeletal factors in anterior open bite and deep over bite. Am J Orthod., 56: 114-127, 1969.
88. Richardson AR: Dento-alveolar factors in anterior open bite and deep over bite. Dent Pract Dent Rec., 21: 53-57, 1970.
89. Ricketts RM.: The influence of orthodontic treatment on facial growth and development. Angle Orthod., 30:103-33, 1960.
90. Ricketts R.: Respiratory obstruction syndrome. Am. J. Orthod., 54:495-507, 1968.
91. Robert, Kuster, Benget Ingervall.: The effects of treatment of skeletal open bite with two types of bite-blocks. Eur J Orthod., 14:489-499, 1992.
92. Rubin R. M.: Facial deformity: A preventive disease. Angle Orthod., 49:98-103, 1979.
93. Safirstein G.R , Burton D.J. Open bite a case report(1965-1982). Am J Orthod 1983;83:47-55
94. Sarver , Weissman.: Case report: non surgical treatment of open bite in non growing patients. Am J Orthod., 108:651-9, 1995.
95. Sarver D., Weissman N, Non surgical treatment of open bite in non growing children. Am J Orthod., 108: 651-9, 1995.

96. Sassouni V., Nanda S.: Analysis of dentofacial vertical proportions. *Am J Orthod.*, 50:801-23, 1964.
97. Sassouni V.: A classification of skeletal facial types. *Am J Orthod.*, 55:109-123, 1969.
98. Schendel SA.: The long face syndrome: vertical maxillary excess. *Am J Orthod.*, 70:398-408, 1976.
99. Schudy FF.: Vertical growth vs. anterioposterior growth as related to function and treatment. *Angle Orthod.*, 34:75-93, 1964.
100. Schudy FF.: The rotation of the mandible resulting from growth: its implication in orthodontic treatment. *Angle Orthod.*, 35:36-50, 1965.
101. Shapiro. Peter A.: Stability of open bite treatment. *Am J Orthod.*, 6:121, 2000.
102. Sheridan J., Mcfall J., Layfield L.: Force-amplified retention for corrected anterior open bite. *J Clin Orthod.*, 12: 817-820, 1997.
103. Snyder D.: Case report: An American board of orthodontics case report. *Am J Orthod.*, 95:451-456, 1989.
104. Spiedel T.M, Issacson R.J, Worms F.W. Tongue thrust therapy and anterior open bite. *Am J Orthod.*, 62:287-95, 1972.
105. Stephen A, Schendel , Jerome H, EisenFeld, William H. Bell, , Bruce N. Epker.: Superior repositioning of the maxilla: Stability and soft tissue osseous relations. *Am J Orthod.*, 70:663-74, 1976.
106. Straub W: Malfunction of the tongue. Part 1. The abnormal swallowing habit: Its causes, effects, and results in relation to orthodontic treatment and speech therapy. *Am J Orthod.*, 46: 404, 1960.
107. Subtelny JD., Sakuda M.: Open bite: diagnosis and treatment. *Am J Orthod.*, 50:337-58, 1964.
108. Subtelny J. D.: The significance of adenoid tissue in orthodontics. *Angle Orthod.*, 24:59-69, 1954.
109. Subtelny J. D.: Oral respiration: facial maldevelopment and corrective dentofacial orthopedics. *Angle Orthod.*, 50:147-164, 1980.

110. Subtelny JD, Subtelny JD: Oral habits— Studies in form, function, and therapy. *Angle Orthod.*, 43: 347-383, 1973.
111. Swinehart E.: A clinical study of open bite *Am J Orthod Oral Surg.*, 28:18-34, 1942
112. Tallas M., Tallas L., Baker R.: Soft tissue profile changes resulting from retraction of maxillary central incisors. *Am J Orthod.*, 91:385-94, 1987.
113. Taylor RG., Mills PB, Brenner LD.: Maxillary and mandibular subapical osteotomies for the correction of anterior open-bite. *Oral Surg Oral Med Oral Pathol.*, 23:141-7, 1967.
114. Tulley W.: A critical appraisal to tongue thrusting. *Am J Orthod.*, 55:640, 1969.
115. Tweed C. H.: *Clinical orthodontics*. Mosby, St. Louis. 1966.
116. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H.: Skeletal anchorage system for open bite correction. *Am J Orthod.*, 115:166-74, 1999.
117. Ward MM: Articulation variations associated with visceral swallowing and malocclusion. *J Speech Hear Disord* 26: 334, 1961.
118. Wesserberg G, Washburn M, Iabank J, Epker B.: Effect of surgical repositioning of the maxilla on mandibular resting posture. *Am J Orthod.*, 81:465-72, 1982.
119. Worms F., Meskin L., Isaacson R.: Open bite. *Am J Orthod.*, 59:589-95, 1971.
120. Zuroff J.: *Orthodontic treatment of anterior open-bite malocclusion: stability ten years post-retention [thesis]*. Seattle: University of Washington; 1990.

10. BIOGRAPHY

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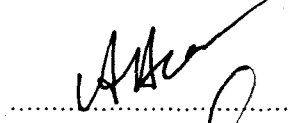


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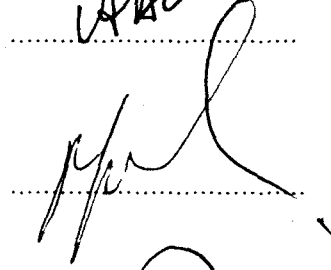
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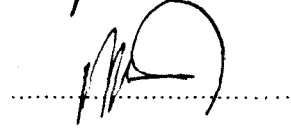
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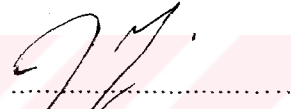
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Prof.Dr. Sevim ROLLAS
Müdür