Journal of American Science

Websites:
http://www.jofamericanscience.org
http://www.sciencepub.net

Emails:
editor@sciencepub.net
sciencepub@gmail.com

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Cephalometric Evaluation of Skeletal Anterior Open Bite Cases Treated by Intrusion of Maxillary Posterior Segments via Miniscrews

Mohamed Elsayed Saad Ebrahim

Department of Orthodontic, Faculty of Dentistry, Menia University, Egypt.

Abstract: Introduction: There are no exaggeration to say that treatment of an anterior open bite cases are challenging orthodontic problem to treat. Surgical and non-surgical correction of anterior open bite are aiming to obtain an adequate amount of overlap of the maxillary and mandibular anterior teeth. The aim of this study is to evaluate the cephalometric changes and amount of molar intrusion obtained by the use of bonded acrylic hyrax supported by four miniscrews as an anchorage for intrusion of maxillary posterior buccal segment. **Materials and Methods:** The selected sample size was ten patients (4 males and 6 females), ranging from 15.6 to 31.1 years of age (mean 21.30 years, SD ± 5.91 years), with skeletal anterior open bite were treated by intrusion of maxillary buccal posterior segment with miniscrews assisted intrusive device system which composed of four miniscrews (Anchor unit), bonded acrylic maxillary hyrax expander with bite blocks (Reactive unit) and Nickel Titanium closed coil spring. Pre-treatment and Post-treatment lateral cephalograms were compared. **Results:** Maxillary first molars were intruded significantly by -2.95 mm + 1.04 mm ($P<0.005$). The lower anterior facial height was reduced statistically by -3.30 mm + 1.16 mm ($P<0.005$). **Conclusion:** Miniscrews assisted acrylic bonded hyrax expander can provide effective and efficient intrusion for maxillary posterior buccal segment to correct anterior open bite (AOB). Controlling the vertical position of lower mandibular posterior buccal segment is the key element in obtaining a significant decrease in lower anterior facial height and reduction of facial convexity by the forward movement of the chin.

[Mohamed Elsayed Saad Ebrahim. **Cephalometric Evaluation of Skeletal Anterior Open Bite Cases Treated by Intrusion of Maxillary Posterior Segments via Miniscrews.** *J Am Sci* 2020;16(7):43-60]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 7. doi:10.7537/marsjas160720.07.

Keywords: Skeletal Anterior, Intrusion, Maxillary Posterior, Miniscrews, Anterior Open Bite (AOB).

1. Introduction:

There are no exaggeration to say that treatment of an anterior open bite cases are challenging orthodontic problem to treat. Surgical and non-surgical correction of anterior open bite are aiming to obtain an adequate amount of overlap of the maxillary and mandibular anterior teeth.

Many Orthodontic Camouflage modalities have been used to close anterior open bite such as multiloop edgewise archwire technique [(1)], extractions [(2)], extrusion of anterior teeth via intermaxillary elastics [(3)], magnets [(4)], High-pull headgear with or without functional appliances [(5)], high-pull chin cup therapy [(6)], spring-loaded bite blocks [(7)]. In spite of all above mentioned treatment options are effective in correction of dental anterior open bite in non-growing patients. However, they are ineffective in changing the skeletal pattern significantly [(8)].

The orthognatic surgery is highly effective in repositioning of jaw bases to create significant mandibular rotation, upward and forward movement of chin botton, and reducing the lower facial height along with correction of open bite [(9-11)]. It was interesting that significant treatment results can be achieved by surgical correction. However, the main drawbacks were complexity, risks and the cost of orthognatic surgery [(12)].

Recently, skeletal anchorage devices such as Dental implants [(13-14)], miniplates [(15-16)], onplants [(17-18)], and miniscrews [(19-20)] have been used as alternative treatment modality to intrude maxillary posterior teeth to correct the skeletal open bite rather than surgical option. Most of studies used miniscrews in treatment of open bite malocclusion rather than various skeletal anchorage devices. Miniscrews are relatively simple and easy to insert, less traumatic, low cost, stable anchorage unit [(21-22)] and possibility to apply force immediately after insertion [(23)].

Molar Intrusions via miniscrews have been described to provide favourable facial changes with closure of anterior open bite [(24)]. It has been reported that intrusion of posterior teeth provides a more stable treatment results than extrusion of anterior teeth [(25)]. Since, the tendency of relapse is higher in adult [(26)], it is important to choose stable and predictable treatment method.

Regarding to miniscrew placement site to intrude molars; it can be placed palatally, or buccally or in both sides. However, the placement site depends on the design of orthodontic appliance present during molar intrusion stage [27-29]. The Appliance design and miniscrew placement site should provide three dimensional control over the buccal posterior segment to achieve adequate results and to avoid unwanted tooth movement [30]. During sifting the literature, there have been no previous study on the use of bonded acrylic Hyrax with ball clasps supported by four miniscrews to intrude maxillary buccal segment to correct the skeletal anterior open bite.

The aim of this study is to evaluate the Cephalometric changes and amount of molar intrusion obtained by the use of bonded acrylic Hyrax supported by four miniscrews as an anchorage for intrusion of maxillary posterior buccal segment.

2. Materials and Methods:

Patient Selection:

Twelve patients (5 males and 7 females), ranging from 15.6 to 31.1 years of age (mean 21.30 years, SD± 5.91), were included in the study. Selection criteria for the study were:

A. Patient's growth completed or primarily completed.

B. Long face pattern with anterior open bite.

C. Mild to Moderate Class II skeletal relationship.

D. Non-acceptance of orthognathic surgery.

E. Patients with active periodontal disease or severe gingival inflammation were excluded.

F. No previous orthodontic treatment.

G. No congenital or developmental dental anomalies had to be found.

H. No previous extractions.

I. Insignificant medical history (patients with physical, psychological or medical limitations were excluded).

J. Acceptance of proposed treatment protocol.

Initial sample size (twelve patients) were dropped because two of them (One Male and One Female) were travelled abroad because of study purpose. So, the final selected sample size was ten patients (4 males and 6 females) Table (1). All patients and/or their parents or guardians had been informed about the purpose of the study, and the possible complications, and had signed an informed consent (Appendix I).

After the selected sample was resolved, the following steps were done for all of them:

I - The Diagnostic Records:

1. Thorough medical and dental history. (Appendix II)
2. Clinical examination. (Appendix II)
3. Intra-oral and Extra-oral photographs (Before and After intrusion of maxillary posterior segment). Fig. (1-A & B), Fig. (2-A & B).
4. Radiographic Examination (Before and After intrusion of maxillary posterior segment):

A. Panoramic Radiographs Fig. (3).

B. Lateral Cephalometric Radiographs Fig. (4).

II. Appliances used in the Study:

1. Acrylic Bonded Hyrax Expander with ball clasps.

Most of the items related to fabrication of acrylic bonded hyrax expander with ball clasp will be explained as follows:

A. Maxillary Expander Kit:

It was composed of the standard rapid palatal expander with maximum aperture of 9mm and safety swivel key [31]. The mid palatal screw is designed with antirotation mechanism and full turn equals 0.8mm (item #19-531-101, International orthodontic service, 12811 Capricorn St., Stafford, TX 77477USA).

B. Construction of the Appliance:

Acrylic bonded hyrax expander with ball clasp was made for each patient in the following sequence:

(1) Long flange orthodontic tray (Duralock Plus Impression Tray, Orthotechnology, 4614 Petlane, Suite D-101, Lutz, Florida 33559, USA) were used to take impression for upper dental arch using fast setting alginate (Hydrogum fast setting, ref C302060, Zhermack, 45021 Badia Polsine (Rovigo), Italy) impression material. The impression was poured immediately in dental stone (type 3 model stone, 309941 Hydrock Model Stone, Kerr Lab, 200 Skraemer Blvd, Building E2, Brea, CA 92821, USA). Trimming of the cast was done after complete setting. Then, the mid palatal jack screw was adapted on the working model over the mid palatine raphae at the first permanent molar area and away from palatal vault by at least 5mm via modelling wax. The Hyrax's arms were adapted on the lingual surfaces of upper premolars and molars. However, these arms were away from the palatal surfaces by at least 1 mm to give space for acrylic material to be trapped between tooth surfaces and Hyrax's arms. The orthodontic cold cure acrylic resin (Orthocryl Dentaurum, Germany) was used to form the acrylic cap over the upper molars and premolars. The acrylic powder was sprinkled on the premolars, molars, and hyrax arms [32]. Then, the acrylic monomer was gradually added using a syringe to soak the powder entirely.

The wire frame work of ball clasp was adapted over the embrasure between 1st and 2nd premolars and 1st and 2nd permanent molars occlusal surface of upper second premolar and second permanent molars during sprinkling on the acrylic powder over the occlusal

surfaces of buccal posterior teeth. Then, the appliance was ground, finished and polished. Before cementation of Acrylic Bonded Hyrax Expander with ball clasps, the upper third molars was extracted to provide enough space for maxillary buccal segment intrusion. Latterly, the appliance was cemented into place using glass ionomer cement (Medicem, Art. No. 2447 Promedica, Domagkstrabe, 24537 Neumunster-Germany).

Most of the study cases had a mild narrow maxillary arch. So, expansion of the maxillary arch was mandatory. Therefore, the maxillary expansion was performed following the active intrusion phase [33].

2. Miniscrews Placement Procedure. Fig. (6) & Fig. (7).

The miniscrews placement procedure were carried out in aseptic operating field and done in the following sequences:

A. Infiltration anaesthesia (few drops) was done at the maxillary dentoalveolar mucosa.

B. Painting the soft tissues at the site of miniscrew insertion by antiseptic solution (Betaine, Povidone-Iodine, Antiseptic Solution).

C. A periodontal probe was used to create identation line over the gingival tissue between the roots of the teeth. Periapical radiographic verification was done after insertion of miniscrews [34].

D. Four miniscrews were placed as follows:

a) Two self-drilling miniscrews (Vector TAS; length, 8mm; diameter, 1.4mm; ORMCO, 1717 W. Collins Ave. Orange CA 92867, USA) were placed on the buccal side between right and left second maxillary premolars and first maxillary permanent molars or between right and left 1st and 2nd maxillary premolars via using ormco screw driver [35].

b) Two self-drilling miniscrews (Vector TAS; length, 10mm; diameter, 2mm; ORMCO, 1717 W. Collins Ave. Orange CA 92867, USA) were placed by contra-head assembly driver if we inserting them distal to 2nd maxillary permanent molar bilaterally in some cases, we insert 8 mm miniscrews between 1st and 2nd maxillary permanent molar.

c) Post placement instruction was prophylactic antibiotic, pain killer when needed, and strict oral hygiene measures [36].

E. The miniscrews were left unloaded in their places for at least 6 weeks to achieve partial osseointegration [37].

F. The miniscrews were loaded by double delta closed coil spring (Length 5mm, 150gm, Ormco, 1717W Collins Ave. Orange CA 92867, USA). One Delta end of closed coil spring was attached on the triangular head of Vector TAS miniscrew and the other end attached on the ball clasp of Acrylic bonded Hyrax expander.

G. The duration of buccal maxillary posterior segment was ranged from 6ms to 9ms. This period depends on fading the cant between the occlusal and incisal plane.

H. In 2 patients, 3 miniscrews were becoming loose and replaced immediately so that, there were no interruption in the intrusion force during active intrusion period.

III. Lateral Cephalometric Measurements:

For each patient, two Lateral Cephalometric radiographs were taken. First radiograph was taken before the beginning of the treatment (preoperative radiograph), the Second one was taken after intrusion of buccal posterior maxillary segment (postoperative radiograph). The Cephalograms were traced on 0.003 inch transparent acetate tracing paper (straight line, acetate tracing paper, G & H wire company, P.O. Box 248, Green Wood, IN46142, USA) using 0.5mm hard lead propelling pencil. Tracing was carried out in a darkened room on a light viewing box. All the area of the light viewing box was shielded with a black sheet of paper to block out any extraneous light except the area being traced [38].

Lateral Cephalometric landmarks (points and planes) used in this study were identified [39, 40, 41] Fig. (7), Appendix (IV). The following linear and angular parameters were measured to the nearest 0.5mm and degree fro Lateral Cephalometric radiograph:

1- Lateral Cephalometric Skeletal Angular measurements: Fig. (8)

A. The anteroposterior position of the maxilla relative to the cranial base (SNA).

B. The anteroposterior position of the mandible relative to the cranial base (SNB).

C. The anteroposterior position of the maxilla relative to the mandible (ANB).

D. The anteroposterior position of the most anterior point of the mandibular symphysis relative to cranial base (SN-Pog).

E. The vertical position of the Mandibular in relation to Maxillary plane (Mx-Md).

F. Cephalometric Indicator of the vertical and horizontal coordinates of mandibular growth expressed in degrees of the Inferior facial angle formed by the Intersection of the sella-gnathion plane with the frankfurt horizontal plane (Y-axis).

2- Lateral Cephalometric Linear measurements: Fig. (9)

A. Lateral cephalometric skeletal linear measurement:

The vertical measurements of anterior facial height was calculated by the linear distance between points Menton (Me) and anterior nasal spine (ANS).

B. Lateral Cephalometric Dental Linear measurements:

The following Lateral Cephalometric Dental measurements were used to indicate the vertical crown movements (Intrusion-Extrusion):

(1) U1 to PP: The distance between the incisal edge of the most anterior maxillary incisors (U1) and the palatal plane (PP). The line connecting the Incisal edge to palatal plane should be perpendicular to palatal plane.

(2) U6 to PP: The distance between the crown centroid of the first maxillary permanent molar (CC6) and the palatal plane (PP). This line connecting CC6 to PP should be perpendicular to palatal plane (PP).

(3) L6 to MP: The distance between the crown centroid of the first mandibular permanent molar ($CC\bar{6}$) to mandibular plane. This line connecting CC6 to MP should be perpendicular to MP.

IV. Statistical Analysis:

The collected data was tabulated and statistically analyzed using an IBM Compatible Computer and SPSS version 20.0 statistics software program (SPSS Inc, a subsidiary of IBM, based in Chicago, Illinois) to obtain:

1- Descriptive Statistics:

- Mean (X)
- Standard Deviation (S.D)

All of them were performed for pre-operative intrusion and post-operative intrusion measurements.

2- Paired "t" Test:

Paired "t" test was performed to compare the effect of treatment (pre-versus post-) on different parameters. P value was calculated by Wilcoxon Signed Ranks Test.

3- Intra-Observer Error:

The pre-operative records of all subjects were measured by one observer at two separate occassions. The error of the pre-operative measurements for all parameters were calculated. Paired "t" test was used to evaluate the difference between the two sets of pre-operative measurements.

3. Results

The pre-operative and post-operative cephalometric characteristics as well as paired t-test are shown in Table (2). Statistically significant changes were observed in several cephalometric skeletal and dental parameters. However, there were no significant changes in the anteroposterior position of maxilla relative to cranial base (SNA) and the vertical position of upper maxillary incisors (U1) relative to palatal plane (PP).

A- Skeletal Cephalometric analysis results: Table (2), Fig. (10).

The anteroposterior position of maxilla relative to cranial base (SNA) wasn't changed significantly by 0.10°+ 0.57º (P<0.56).

The anteroposterior position of mandible relative to cranial base (SNB) was increased significantly by 1.85°+ 1.01º (P<0.007). The horizontal relation of maxilla relative to the mandible (ANB) was decreased statistically by -1.65°+ 1.25° (P<0.01).

The most anterior point of the mandibular symphysis relative to cranial base (SN-Pog) was increased significantly by 1.85°+ 1.01° (P<0.007).

The correction of anterior open bite was achieved by significant anti-clockwise rotation of the mandible. This was interpreted by decreasing the maxillary-mandibular angle significantly by -3.75°+ 1.55° (P<0.005). The growth axis indicator (Y-axis) was shown a significant horizontal changes by -3.40°+ 2.18° (P<0.007). Last but not least, the lower anterior facial height was reduced significantly by -3.30 mm + 1.16 mm (P<0.0-005).

B- Dental Cephalometric Analysis result: Table (2), Fig. (11).

The maxillary and mandibular first permanent molars was intruded significantly by -2.95 mm + 1.4 mm (P<0.005) and -0.80 mm + 0.54 mm (P<0.007) respectively. The maxillary central incisors wasn't changed vertically -0.45 mm + 2.11 mm (P<0.79).

C- Intra-observer error results: Table (3).

The pre-operative measurements for all variables in skeletal and dental cephalometric measurements at different occasions to evaluate the Intra-observer accuracy was varied insignificantly.

Table (1): Showing the sample characteristics of the study group.

Sample Characteristics	N (%)
Sex	
Male	4 (40%)
Female	6 (60%)
Age (mean ±SD)	21.30±5.91
Range	(15 – 31)

APPENDIX 1

Informed Consent

□ Surgical Orthodontic Procedure □ Invasive Orthodontic Procedure

□ Orthognatic Procedure

I _____ authorize Dr.Mohamed Elsayed Ebrahim

Name of Patient □ Treating Physician

and his/her associates to perform the following procedure:

Placement of four miniscrews + bonding of Hyrax Expander + Orthodontic treatment

"First Phase" "Second Phase"

for me including the performance of any additional procedures that in his/her judgment may be advisable and medically necessary for my well being.

My treating Dentist has explained to me the nature of the procedures/treatment:

Potential benefits are Closure of Anterior open bite .

Possible alternatives are Extraction of premolars and/or Orthognatic Surgery .

Likelihood of successful procedure/treatment 80% .

Possible complications Root Resorption, Gum Inflammation, Looseness of miniscrews and reinsertion of them again, Caries, Difficulty in chewing and talking at the beginning of treatment.

Possible results of not doing the procedure No Correction of Anterior Open Bite .

I have had the opportunity to ask questions and my questions have been answered to my satisfaction, No warranty or guarantee has been given to me. I, therefore, consent for above mentioned procedure/treatment.

□ The consent has been read □ Translated to patient by: Name:_____Signature:_____

Patient Name:	Signature:	Date/Time:
Treating Physician:	Signature:	Date/Time:
Witness Name:	Signature:	Date/Time:

When the patient is not capable of consenting, a guardian may sign instead because of:

- The patient is minor under 18 years.
- The patient is unconscious or mentally incompetent
- Others:_____

Guardian Name:	Signature:	Date/Time:
Relation to the Patient:		

Informed Consent Is Every Patient's Right

APPENDIX II

Identification & Medical History Report Form

Name:_____ Date:_____ School:_____ Grade:_____

Age:____yrs,_____ms. DOB:___/___/19 Parent's Name:_____

Height:_____Weight:_____ Occupation:_____

Home Address:_____ Business Address & Phone:_____

Phone:_____ Social State: Married / Divorced / Widowed

Hobbies/ Favorite Sports:_____ No. Of siblings and ages:_____

Referred by:_____ Physician's Name & Address:_____

Are you in good health?_____ 2. Do you receive regular medication?_____

If so, for what condition?_____ 4. Do you bleed excessively if cut?_____

Are you sensitive to Penicillin, Aspirin, Sulfa or Other?_____

Have you had any of the following:

	Yes	No		Yes	No
Allergy/ Sinusitis			Heart Problem		
Asthma			Hepatitis		
Abnormal Blood Pressure			Liver Disease		
Anemia			T.B.		
Rheumatoid Arthritis			Thyroid Problems		
Diabetes Mellitus			Tonsillectomy/ Adenoidectomy		
Epilepsy			Have you ever been hospitalized?		
Recurrent Fainting			If so, for what condition?		
Rheumatic fever			Any head and neck trauma?		

How often do you brush your teeth? - Have any of your teeth ever received a trauma?____

_____

Do you floss?___ Type of Toothbrush:_____ - Have you received any orthodontic treatment?____

Do your gums bleed easily?_____ - Have you ever complained of pain or clicking

Date of last dental exam:_____where? infront of your ears?_____

_____

Have you had any dental extractions or - Have you ever had any oral habits e.g thumb sucking,

Endodontic treatment?_____when?_____ nail biting, clenching or mouth breathing?_____

Has any of your friends worn braces?_____ - How do you feel about wearing braces?_____

Patient or Guardian's Details	Name:
Signature:	Date:
Physician/Dentist's Details	Name:
Signature	Date:

APPENDIX III

CLINICAL EXAMINATION FORM

Resident:_____ **Consultant:**_____

PATIENT:_____ AGE:____ y____ ms DOB:___/___/___ SEX:_____

CHIEF COMPLAINT: DATE: / /

FACIAL / SOFT TISSUES

Facial Type	**Symmetry**	**Lips**	**Respiration**
☐ Mesocephalic	☐ Symmetric	☐ Relaxed & Together	☐ Nasal
☐ Brachycephalic	☐ Asymmetric	☐ Strained & Together	☐ Oral
☐ Dolichocephalic			☐ Both

Occlusal Plane ☐ Parallel ☐ Tipped

Chin	**Profile**	**Nasolabial Angle**
☐ Orthognathic	☐ Straight	☐ Normal
☐ Retrognathic	☐ Convex	☐ Obtuse
☐ Prognathic	☐ Concave	☐ Acute

Nose:_____ U. Lip:_____

Mentolabial Sulcus:_____ L. Lip:_____

U. Lip Length:_____ mm Tooth at Rest:____ mm Tooth at Smile:_____

Maxillary Midline ☐ On Facial ☐ To Right___ mm ☐ To Left___ mm

Mandibular Midline ☐ On Facial ☐ To Right___ mm ☐ To Left___ mm

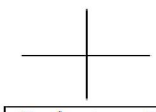
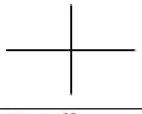
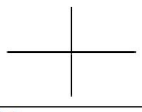
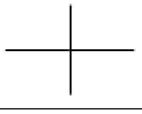
PERIODONTAL STATUS:

Gingiva	**Attached Gingiva**	**Periodontal Pockets**	**Frenal Attachment**
☐ Normal	☐ Adequate	☐ Absent	☐ Normal
☐ Edematous	☐ Thin	☐ Present	☐ Abnormal
☐ Hypertrophic	☐ Recession		

Oral Hygiene:_____ Habits:_____

Attitude: ☐ Enthusiastic ☐ Acceptable ☐ Unreceptive

DENTAL STATUS:

Carious	**Missing**	**Hypoplastic**	**Fillings**
			

Patient or Guardian's Details	Name:
Signature:	Date:
Physician/Dentist's Details	Name:
Signature	Date:

Fig. (1-A): Pre-operative Extra-oral photographs showing:
a) Frontal view.
b) Frontal view with pose smile.
c) Lateral view.

Fig. (1-B): Post-operative Extra-oral photographs showing:

a) Frontal view.
b) Frontal view with pose smile.
c) Lateral view.

Fig. (2-A): Pre-operative Intra-oral photographs showing:

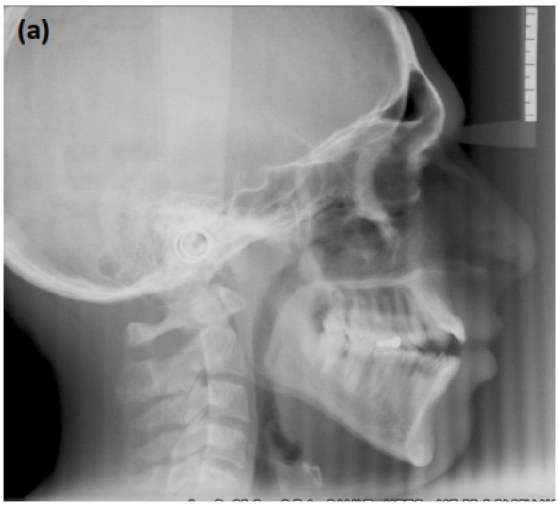
a) Frontal view that shows the anterior open bite (6mm).
b) Lateral view right side.
c) Lateral view left side.

Fig. (2-B): Post-operative Intra-oral photographs showing:

a) Frontal view.
b) Lateral view right side.
c) Lateral view left side.

Fig. (3):

a) Pre-operative Panoramic view before intrusion of maxillary posterior segment.
b) Post-operative panoramic view after intrusion of maxillary posterior segment.



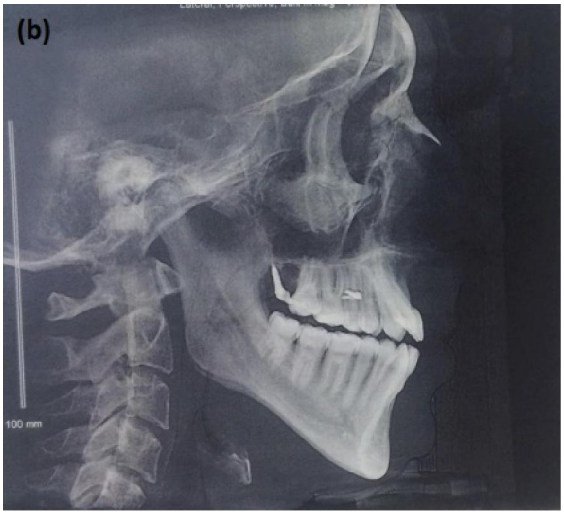


Fig. (4):

a) Pre-operative Lateral Cephalometric view before intrusion of maxillary segment.
b) Post-operative Lateral Cephalometric view after intrusion of maxillary segment.

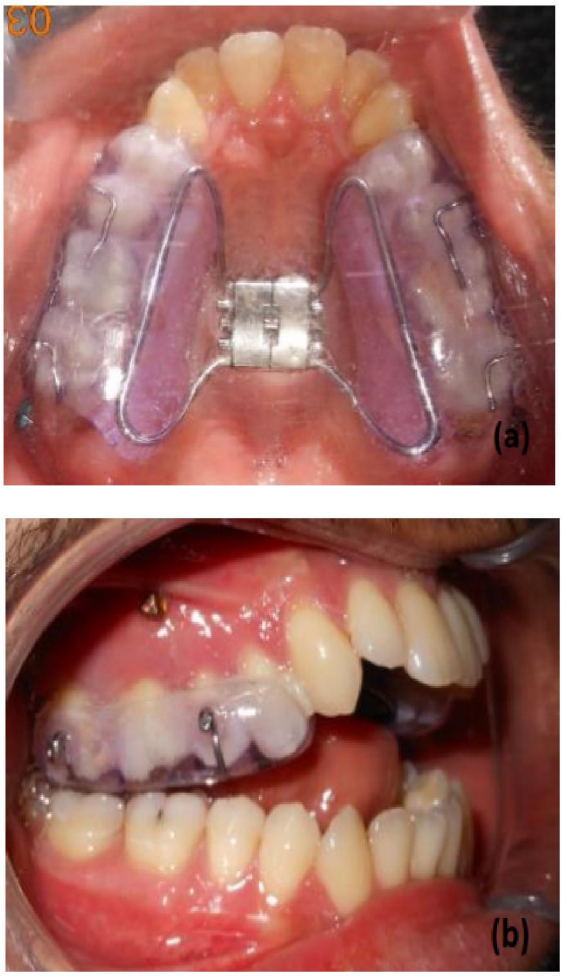


Fig. (5): Intra-oral photograph showing Acrylic bonded Hyrax expander with ball clasp cemented in place:
a) Occlusal view.
b) Lateral view right side.
c) Lateral view left side.

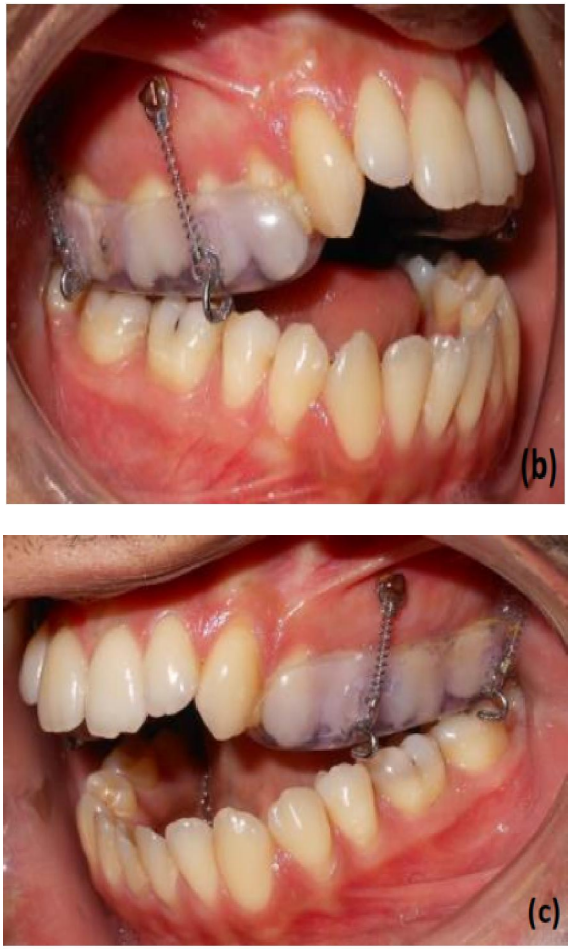


Fig. (6): Intra-oral photograph showing Acrylic bonded Hyrax expander with ball clasps loaded with close coil spring
a) Frontal view.
b) Lateral view right side.
c) Lateral view left side

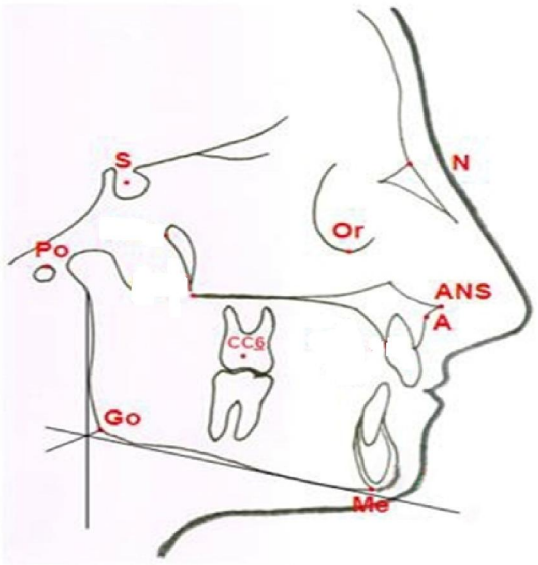


Fig. (7): Showing Lateral Cephalometric Landmarks used in the study

Appendix Iv

The lateral cephalometric reference points used in this study were located on or within the skeletal and dental structures and defined as follows:

Number	Code	Definition
1	**N**	**Nasion:** the most anterior point of the nasofrontal suture in the median plane.
2	**S**	**Sella:** the midpoint of the hypophysial fossa (sella turcica) in the median plane.
3	**A**	**Point A, subspinale:** the deepest midline point in the curved bony outline from the base to the alveolar process of the maxilla.
4	B	**Point B, supramentale:** the deepest midline point in the curved bony outline from the base to the alveolar process of the mandible.
5	**Me**	**Menton:** the most caudal point in the outline of the symphysis.
6	**Go**	**Gonion:** a constructed point, the intersection of the lines tangent to the posterior margin of the ascending ramus and the mandibular base.
7	**ANS**	**Anterior nasal spine:** the tip of the bony anterior nasal spine, in the median plane.
8	**PNS**	**Posterior nasal spine:** the intersection of a continuation of the anterior wall of the pterygoid palatine fossa and the floor of the nose.
9	**Or**	**Orbitale:** the lower most point of the orbit in the radiograph.
10	**Po**	**Porion:** the midpoint of the upper contour of the external auditory meatus canal (anatomic porion), or the midpoint of the upper contour of the metal ear rod of the cephalometer (machine porion).
11	**Pog**	**Pogonion** the most projecting median point on the anterior surface of the chin.
12	**Gn**	**Gnathion** the lowest point on the anterior margin of the lower jaw in the midsaggital plane.
13	**U 1**	**U1: the** midpoint incisal edge of the most anterior maxillary incisor.
14	**CC $\bar{6}$**	**Crown centroid $\bar{6}$:** midpoint at the center of the crown of the mandibular first premolar.
15	**CC 6**	**Crown centroid 6:** midpoint at the center of the crown of the maxillary first permanent molar.

The lateral cephalometric reference lines or planes used in this study were constructed before angular and linear measurements and defined as follows:

Number	Code	Definition
1	**S-N**	**Sella-Nasion:** anterior cranial base line joining point sella and nasion.
2	**FH**	**Frankfort Horizontal:** line joining point Or and Po.
3	**PP**	**Palatal Plane:** maxillary plane; line joining point ANS and PNS.
4	**MP**	**Mandibular Plane:** line joining point Me and Go.

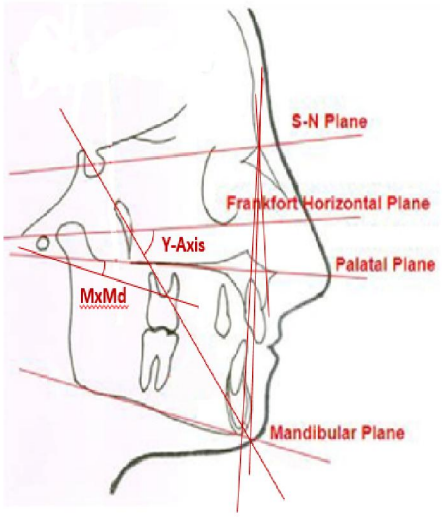


Fig. (8): Showing Lateral Cephalometric Skeletal Angular Measurements.

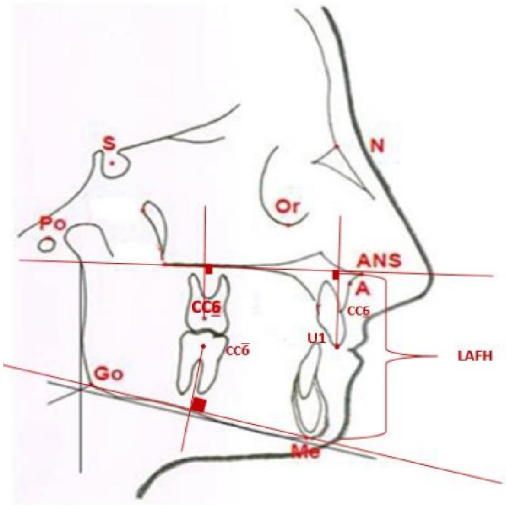


Fig. (9): Showing Lateral Cephalometric Skeletal and Dental Linear Measurements.

Table (2): Showing pre-treatment post-treatment cephalometric measurements.

	Pre-operative Miniscrews (Mean ± SD)	**Post-operative Miniscrews** (Mean ± SD)	**Difference** (Mean ± SD)	**P value**
Skeletal analysis				
SNA°	78.65° ± 2.56°	78.75° ± 2.84°	0.10° ± 0.57°	0.56
SNB°	76.50° ± 2.54°	78.35° ± 2.64°	1.85° ± 1.01°	0.007*
ANB°	2.15° ± 1.67°	0.50° ± 1.11°	-1.65° ± 1.25°	0.01*
SN-Pog°	77.30° ± 2.58°	79.15° ± 2.68°	1.85° ± 1.01°	0.007*
Mx-Md°	34.20° ± 4.26°	30.45° ± 3.45°	-3.75° ± 1.55°	0.005*
Y-Axis°	66.10° ± 5.59°	62.70° ± 4.89°	-3.40° ± 2.18°	0.007*
LAFH (mm)	71.50 ± 6.69 mm	68.20 ± 6.39mm	-3.30 ±1.16 mm	0.005*
Dental analysis (mm)				
U1 to PP	27.00±5.09mm	26.55±5.12mm	-0.45±2.11 mm	0.79
U6 to PP	24.75±6.24mm	21.80±5.92mm	-2.95±1.04 mm	0.005*
L6 to MP	34.50±9.03mm	33.70±9.04mm	-0.80±0.54mm	0.007*

Difference = post-operative – pre-operative; P value calculated by Wilcoxon Signed Ranks Test.

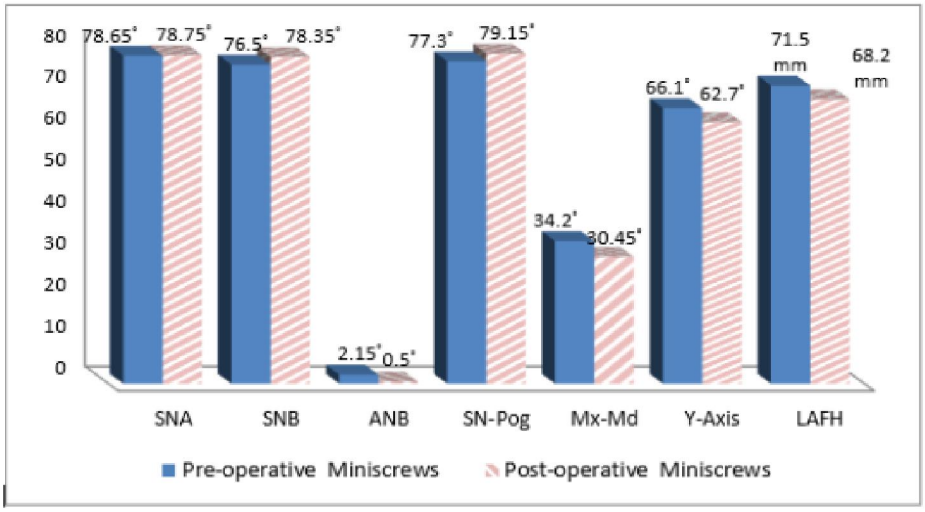


Fig. (10): Showing bar graph representing mean of lateral cephalometric skeletal angular and linear changes in pre and post-operative measurements.

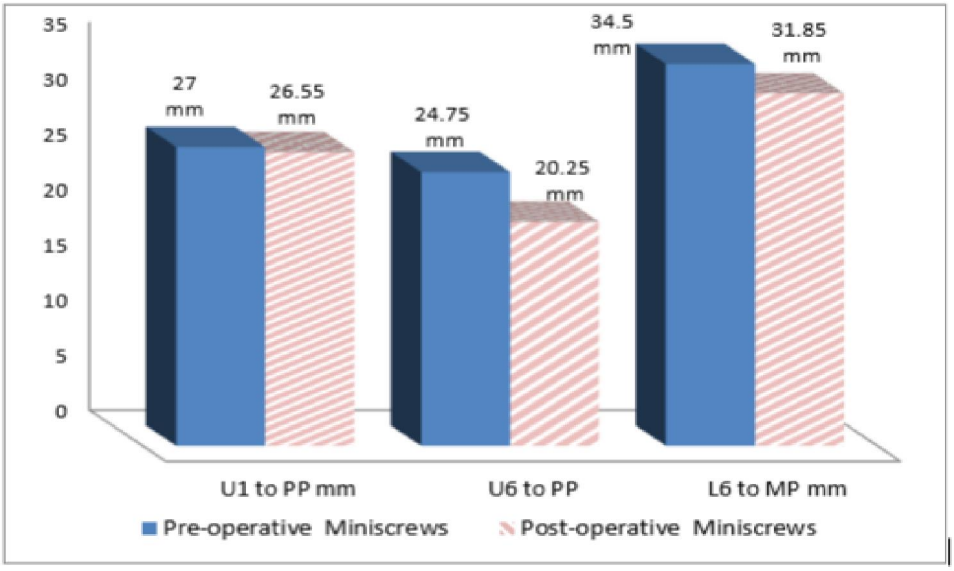


Fig. (11): Showing bar graph representing mean of lateral cephalometric dental linear changes in pre and post-operative measurements.

Table (3): Comparison of mean and intra observer variation for pre-operative miniscrews between first and second reading (N= 10)

	First reading Mean ± SD))	**Second reading** Mean ± SD))	**P value**
Skeletal analysis			
SNA°	78.65° ± 2.56°	78.70° ± 2.53°	0.94
SNB°	76.50° ± 2.54°	76.55° ± 2.49°	0.94
ANB°	2.15° ± 1.67°	2.20° ± 1.64°	0.80
SN-Pog°	77.30° ± 2.58°	77.35° ± 2.69°	0.94
Mx-Md°	34.20° ± 4.26°	34.25° ± 4.25°	0.97
Y-Axis°	66.10° ± 5.59°	66.25° ± 5.58°	0.94
LAFH (mm)	71.50 ± 6.69 mm	71.70 ± 6.82mm	0.82
U1 to PP	27.00±5.09mm	26.90±5.02mm	0.85
U6 to PP	24.75±6.24mm	24.85±6.07mm	0.94
L6 to MP	34.50±9.03mm	34.60±8.86 mm	0.94

P value calculated by Mann-Whitney test.

Table (4): Showing duration of active intrusion period for miniscrews group.

	Duration (month)	
	Mean ±SD	**Range**
Miniscrews sample	8.50 ±2.62	(5-13.5)

4. Discussion

Many studies showed that molar intrusion is possible to be performed orthodontically via various orthodontic treatment mechanics. However, accurate cephalometric evaluation of the amount of molar intrusion depends on the reference planes and points [(42)]. The appropriate reference planes (palatal and mandibular plane) were used in the current study. These planes represent the basal osseous bone for their corresponding molars [(41)]. It was interesting that the centre of molar crowns (crown centroid) were used as a reference point to quantify the amount of molar intrusion, using the cusp tips or root apices would not act as a reliable reference point because crown or root tipping might be happened during molar intrusion leading to false evaluation [(43)].

Through sifting the literature, we found that most of miniscrews assisted intrusive appliances consisted of specific wire frame work design to hold the maxillary posterior dentitions (reactive unit) and particular number of miniscrews (Anchor Unit) connecting to each other via certain force system such as power chain modules, stainless steel ligature, specific springs or closed coil spring to correct anterior open bite orthodontically.

Deguchi et al. (2011) [44] used 4 miniscrews (two in maxillary buccal alveolar ridge and two in mandibular buccal alveolar ridge) placed between either the second premolar and first permanent molar or the first permanent molar and second permanent molar in the buccal region (one miniscrew on each side). Intrusion of posterior buccal segment was applied by using either a power chain modules or stainless steel ligature wires from the miniscrews to the sectional stainless steel 0.016" x 0.022" arch wire extended from the second premolar to the second permanent molar. The active intrusion time and amount of force level applied were not declared in this study. They reported that the amount of first maxillary permanent molar intrusion and the amount of decrease of lower anterior facial height were -2.3 mm and -2.6 mm respectively. The mean age of the sample was 24.3 yrs.

Xun et al. (2007) [19] stated that the amount of upper posterior segment intrusion, and the changes of lower anterior facial height and maxillomandibular plane angle were -1.8 mm, -1.6 mm and-2.5 mm respectively. They used 3 miniscrews distributed as follows: one miniscrew inserted into midpalatal area of the maxilla and two minscrews inserted into the buccal mandibular alveolar bone between first and second permanent molars. Intrusion of maxillary posterior buccal segment was performed by using powerchain to connect the miniscrew to traction hooks of the transpalatal arch. Regarding to lower arch, the powerchain was connected to the main arch wire 0.019" x 0.025" stainless steel rectangular arch wire between last molars. The lower first permanent molars was supported by lingual arch. The active intrusion period and the magnitude of force level were 6.8 months and 150g per side. The mean age of the sample was 18.7 yrs.

Schiffler et al. (2014) [45] reported that miniscrews aided intrusive appliance system was composed of one miniscrew on each side of maxilla placed at the base of maxillary arch and nickel titanium coil spring to deliver the intrusive force to bonded hyrax expander splint. They found out that the mean of first maxillary molar intrusion and lower anterior facial height were -2.3 mm and -1.6 mm respectively. the active intrusion time was 5 months. While, the amount of applied force was 150g per side. The mean age of the sample was 24.1 years.

Foot et al. (2014) [46] utilized miniscrews assisted intrusive device system composed of 2 miniscrews, one of them placed between the upper first and the second premolar and the other one placed between second premolar and the upper first permanent premolar on both side, bonded acrylic maxillary hyrax expander with shallow bite plate, and Sydney intrusion spring (SIS). They stated that the amount of mean molar intrusion, lower facial height and maxillomandibular plane angle were -2.9 mm, -0.9 mm and -1º. The active intrusion time and the amount of force level applied were 4.91 months and 500g per side. The mean age of the sample was 13.1 years.

Hart et al. (2015) [24] used a miniscrews aided intrusive appliance consisted of one miniscrew in the midpalatal area of maxilla or two miniscrews in bilateral palatal alveolar process, traction hooks soldered to modified transpalatal arch or quadhelix expander and powerchain connecting the miniscrews to these appliances. The intrusion period was 5.4 months. The magnitude of force level was not proclaimed. The mean of upper first permanent molar intrusion was -2.3 mm. The mean of decrease in lower anterior facial height was -1.5 mm. The mean age of the sample was 20.7 years.

In the current study, the mean of molar intrusion was statistically significant by -2.95mm (P<0.005). This amount of molar intrusion in current study was higher than those of other studies (-2.3) [19, 24, 44, 45]. This may be attributed to many factors such as follow: Number of miniscrews used, appliance design, amount of force level, duration of active intrusion Table (4), patient's age (dento alveolar growth), orthodontic intrusive mechanics utilized and force system used.

In the present study used 4 miniscrews (2 miniscrews on each side of maxilla) which provided more control and stable force delivery cover over the whole posterior maxillary buccal segment. In addition, the force system was closed coil spring which provided effective sustained continuous force level over the reactive unit. Owman-moll et al. (1995) [47] concluded that tooth movement with continuous force was more effective than interrupted continuous force. In further studies [19, 24, 44], the force system was ligatures or powerchain modules (interrupted continuous force) and number of miniscrews was one miniscrew in the mipalatal area or one on each side of the maxillary alveolar bone. However, the study by schiffler et al. [45] had the same force system (closed coil spring) while the only difference was only one miniscrew on each side. Furthermore, foot et al. [46]study showed 2.9mm molar intrusion which was more or less similar to current study (2.95mm). This results may be attributed to usage of 4 miniscrews and continuous force system (SIS). However, the only difference was force delivery coverage in our study was more than them.

Regarding to LAFH, the present study showed a statistically significant reduction by -3.3mm (P<0.005) which was greater than the previous studies [19, 24, 44, 45, 46]. This difference may be attributed to the dual effect of posterior bite blocks and miniscrew assisted intrusion system. One of the common features of skeletal open bite cases is an increased molar height.

So, limiting excessive dentoalveolar height in upper and lower posterior segment are mandatory [48]. In addition, the mean age of the patient in this study was 21.3 years, indicating that there would be little alveolar bone growth posteriorly during active treatment. Hence, Acrylic Bonded Hyrax expander was used for many options. One of them was to act as posterior bite block to impede the lower posterior alveolar bone growth, control posterior teeth eruption, and permit an upward and forward rotation of the mandible [49, 50]. Stellzig et al. (1999) [51], Kuster & Ingervall (1992) [52], Mavropoulos et al. (2004) [53] and Meibodi et al (2009) [54] stated that the bite block would stimulate the activity of temporalis and masseter muscles consistently and produce an intrusive force against the posterior buccal segment.

A study by Xun et al. [19] showed that the amount of reduction in the maxillomandibular plane angle was -2.5° while our study showed a decrease by -3.3°. It was interesting that how come the amount of upper molar intrusion in Xun et al [19] study was 1.8mm and can produce a decrease in MMPA by -2.5°. In spite of our intrusive appliance system produced -3.3° from -2.95mm upper molar intrusion. Interpretation was assigned to the intrusive system by Xun et al [19] included intrusion of upper and lower molars by -1.8 mm and -1.2 mm respectively. So, the total amount of intrusion was -3 mm which explained that amount of decrease in MMAP by -2.5°. On the other hand, foot et al [46] study showed a decrease in maxillomandibular plane angle by -1° inspite of amount of upper molar intrusion was -2.9mm. This may be attributed to the mean age of their sample was 13.1 yrs. it means that there were active dento alveolar growth. In addition, their intrusive appliance system had a shallow bite blocks which means that there were no intrusive action on the lower posterior buccal segment. So, mean age of the patient's sample and duration of presence of bite blocks played a major role in counter clock-wise rotation of the mandible. In our study, the mean age of the patient's sample was 21.3 years. So, the amount of remaining growth was primarily little. The skeletal angular cephalometric measurements for SNB and ANB in our study were statistically significant increased by +1.85° and decreased by -1.65° respectively. The study by Deguchi et al [44], Xun et al [19], Foot et al. [46] and Hart et al [24] reported the changes in SNB and ANB angles were +1.4° & -1.6°, +1.6° & -1.8°, +0.6° & -0.4°, and +0.6º & -1.1º respectively. The current and previous studied proved that there were mandibular forward rotation which was favourable significant changes in skeletal pattern (Decrease the Skeletal Class II feature) and soft tissue profile (Reduction in facial convexity). In addition, the statistically significant changes in SN-Pog and Y-axis in our study (+1.85°(P<0.005) & -3.40°(P<0.007)) supported that the mandible was significantly rotated counter clock-wise as a result of intrusion mechanics.

The study of Degudchi et al. (2011) [44] and Park et al. (2006) [55] used stainless steel ligature or a ligature wire hook around the neck of miniscrew to connect the elastics. So, we have to pay attention for the miniscrew head before starting treatment to provide better verstality [56]. In current study, we used Vector Tas miniscrew which had a special triangular head design with hole which was suitable for their coil spring accessories or any type of force component.

Acrylic Bonded Hyrax device was a superior choice for our study to avoid unwanted third-order reaction in posterior segment. The force applied from the buccal side which could produce buccal torque problems. These problems was counter acted by the acrylic cover and rigidity of Hyrax appliance. This appliance was found in two previous study [45 & 46] and the rest of studies [19,24] they were used modified TPA. On the other hand, Deguchi et al [44] used sectional archwires of 0.016"x0.022" stainless steel were placed from the second maxillary premolar to the second maxillary molar.

Regarding to optimal force level during maxillary posterior segment intrusion, no one can deny that there were no evidence in the literature about the exact force level. However, Kravitz et al (2007) [57] suggested intrusive force level for single maxillary molar to be 100 – 200g. They study by Kato and Kato (2016) [58] concluded that 300g per side of maxillary posterior buccal segment could produce smooth progressive en masse molar intrusion while using skeletal anchorage. Concerning these studies, the current force level used in our study was 400g per side. However, the current force level distribution was 150g on the anterior part of Acrylic Bonded Hyrax expander and 250g on the posterior part of it. The exact reason for different force level on each side to encourage more posterior intrusion, it means clock wise rotation of maxillary dentition to gain more effective closure for anterior open bite.

One of the most important factor for miniscrew stability in bone depends on the amount of force level. The study by Alrbata et al. (2017) [59] found that the optimal force level that could be safely loaded on to miniscrew should be not excess (382.39g – 458.87g). Fortunately, our force level load was less than this. Because, our force level was ranging from 150gm to 250gm.

It was exciting that no study was negotiating or discussing the importance of upper wisdom extraction before starting intrusion of maxillary posterior dentition. Although, extraction of wisdoms as in our study is very important to give enough space for reactive unit to be intruded and to decrease the resistance towards the Anchor unit.

Conclusion

Miniscrews assisted acrylic bonded hyrax expander can provide effective and efficient intrusion for maxillary posterior buccal segment to correct Anterior Open Bite (AOB). The treatment mechanics for correcting anterior open bite with the current appliance showed significant molar intrusion by -2.95 mm ± 1.04 mm (P<0.005) and mandibular counter clock-wise rotation by -3.75°± 1.55° (P<0.005). Controlling the vertical position of lower mandibular posterior buccal segment is the key element in obtaining a significant decrease in lower anterior facial height by -3.30 mm ± 1.16 mm (P<0.005) and reduction of facial convexity by the forward movement of the chin (SN-Pog) by -1.85° ± 1.01° (P<0.007).

References

1. Kim YH. Anterior openbite and its treatment with multiloop edgewise archwire. Angle Orthod. 1987; 57: 290-321.
2. Aras A. Vertical changes following orthodontic extraction treatment in skeletal open bite subjects. Eur J Orthod. 2002; 24: 407-416.
3. Kucukkeles N, Acar A. Demirkaya AA, Evrenol B, Enacar A. Cephalometric evaluation of open bite treatment with Ni Ti archwires and anterior elastics. Am I Orthod Dentofacial Orthop. 1999; 116: 555-562.
4. Kiliaridis S, Egermark I, Thilander B. Anterior open bite treatment with magnets. Eur J Orthod. 1990; 12: 447-57.
5. Freeman CS, McNamara JA Jr, Baccetti T, Franchi L, Graff TW. Treatment effects of the bionator and High-pull facebow combination followed by fixed Appliances in patients with increased vertical dimensions. Am J Orthod Dentofacial Orthop. 2007; 131: 184-95.
6. Torres F, Almeida RR, de Almeida MR, Almeida-Pedrin RR, Pedrin F, Henriques JF. Anterior open bite treated with a palatal crib & High-pull chin cup therapy. A prospective randomized study. Eur J Orthod. 2006; 28(6): 610-617.
7. Doshi UH. Bhad WA. Spring-Loaded bite blocks for early correction of skeletal open bite associated with thumb sucking. Am J Orthod Dentofacial Orthop. 2011; 40: 115-120.
8. Beane RA. Nonsurgical management of the anterior open bite: a review of the options. Seminars in Orthod. 2000; 5(4): 275-283.
9. Swinnenk, Politis C, Willems G, De Bruyne I, Fieuws S, Heidbuchel K, van Erum R, Verdonck A, Carels C. Skeletal and dento-alveolar stability after Surgical-orthodontic treatment of anterior open bite: a retrospective study. Eur J Orthod. 2001; 23(5): 547-557.
10. Epker BN, Fish LC. Surgical-orthodontic correction of open-bite deformity. Am J Orthod. 1977; 71(3): 278-299.
11. Sperry TP, Steinberg MJ, Gans BJ. Mandibular movement during autorotation as a result of maxillary impaction surgery. Am J Orthod. 1982; 81: 116-123.
12. Park YC, Lee HA, Choi NC, Kim DH. Open bite correction by intrusion of posterior teeth with miniscrews Angle Orthod. 2008; 78(4): 699-710.
13. Kato S. Kato M. Intrusion of molars with Implants as an anchorage: a report of two cases. Clin Implant Dent Retat Res. 2006; 8: 100-106.
14. Roberts WE, Engen DW, Schneider PM, Hohlt WF. Implant-anchored orthodontics for partially edentulous malocclusions in children and adults. Am J Orthod Dentofacial orthop. 2004; 126: 302-304.
15. Erverdi N, Keles A, Nanda R. The Use of Skeletal anchorage in open bite treatment: a cephalometric evaluation. Angle Orthod. 2004; 74: 381-390.
16. Sugawara J, baik UB, Umemori M, Takahashil, Nagasaka H, Kawamura H, Mitani H. Treatment and post treatment dentoalveolar changes following intrusion of mandibular molars with application of a skeletal anchorage system (SAS) for open bite correction. Int J Adult Orthodon Orthognath Surg. 2002; 17: 243-253.
17. Janssens F, Swennen G, Dujardin T, Glineur R, Malvez C. Use of an on plant as orthodontic anchorage. Am J Orthod Dentofacial Orthop. 2002; 122: 566-70.
18. Wehrbein H, Merz BR. Aspects of the use of endosseous palatal implants in orthodontic therapy. J Esthet Dent. 1998; 10: 315-324.
19. Xun C, Zeng X, Wang X. Microscrew anchorage in skeletal anterior open-bite treatment. Angle Orthod. 2007; 77: 47-56.
20. Kravitz ND, Kusnoto B. Posterior impaction with orthodontic miniscrews for openbite closure and improvement of facial profile. World J orthod. 2007; 8: 157-166.
21. Liou EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces?. Am J Orthod Dentofacial Orthop. 2004; 126: 42-47.
22. Garg KK, Gupta M. Assessment of Stability of Orthodontic mini-implants under orthodontic Loading: A Computed Tomography Study. Indian J Dent Les. 2015; 26: 237-243.
23. Sharifi M, Bayani S, Ghassemi A. Effect of Insertion Method and post insertion time interval prior to force Application on the removal torque of orthodontic miniscrews. Int. J of oral and maxillofacial Implants. 2014; 30:1-6.
24. Hart TR, Cousley RRJ, Fishman LS, Tallents RH. Dentoskeletal changes following mini-implant molar intrusion in anterior open bite patients. Angle Orthod. 2015; 85(6): 941-948.
25. Graber TM, Vanarsdall RL, eds. Orthodontics-Current principles and Techniques. 2nd ed. Place of Publication: Mosby; 1994; 168-169.
26. Kahl-Nieke B. Retention and stability considerations for adult patients. Dent Clin North Am. 1996; 40: 961-994.
27. Chang J, Mehta S, Chen PJ, Upadhyay M, Yadav S. Correction of open bite with temporary anchorage

device-supported intrusion. APOS Trends in Orthod. 2019; 9(4): 246-251.
28. Gupta SP. Anterior open bite correction by molar intrusion using temporary anchorage device: A case report. 2019; 3(2): 113-120.
29. Salguero AEM, Valverde AS. Correction of skeletal anterior open bite with miniscrews and a modified bite block. Revista Mexicana de Orthodoncia. 2017; 5(2): e102- e110.
30. Graber TM, Vanarsdal RL VK. Orthodontics. Current principles and techniques. 4th ed; 2005.
31. Shilliday DJ. Swivel Key for palatal expansion appliances. J Clin Orthod. 1992; 26(2): 163.
32. Nik TH, shahroudi AS, Eraghihzadeh Z, and Aghayani F. Comparison of residual monomer loss from cold-cure orthodontic acrylic resins processed by different polymerization techniques. J Orthod. 2014; 41: 30-37.
33. Beycan K, Erverdi N. anterior open bite treatment by means zygomatic miniplates: a case report. J Istanb Univ Fac Dent.2017; 51:52-56.
34. Kravitz ND, Kusnoto B. Placement of mini-implants with topical Anaesthetic. J Clin. Orthod. 2006; 602-604.
35. Poggio PM, Incorvatic C, Velo S, Carano A. "Safe Guide": A Guide for Miniscrew Positioning in the Maxillary and Mandibular Arch. 2006; 76: 191-197.
36. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB, Development of orthodontic micro-implants for Intra-oral anchorage. J Clin Orthod. 2003; 37: 321-328.
37. Vannet BV, Sabzevar MM, Wehrbein H, Asscherickx K. Osseointegration of miniscrews: a histomorphometric evaluation. Eu J Orthod. 2007; 29: 437-442.
38. Mitchell L. An Introduction to orthodontics. Third edition, Oxford University press. 2007; page 63.
39. Chaconas SJ. Orthodontics. PSG Publishing Company, Inc. Littleton, Massachusetts, 1980; pages 35-46.
40. Rakosi T. An atlas and manual of cephalometric radiography. First edition, Lea and febiger-Philadelphia. 1982; pages: 34-45.
41. Athanasiou AE. Orthodontic Cephalometry. First edition. Mosby-wolfe. 1995; 3: 63-103.
42. Ng J, Maj or PW, Flores-Mir C. True molar intrusion attained during orthodontic treatment: A systematic review. AMJ Orthod Dentofacial Orthop. 2006; 130: 709-714.
43. Burstone CR. Deep overbite correction by intrusion. Am J Orthod. 1977; 72: 1-22.
44. Deguchi T, Kurosaka H, Oikawa H, Kurocla S. Takashi I, Yamashiro T, Takano-Yamamoto-Takano T. Comparison of orthodontic treatment outcomes in adults with skeletal open bite between conventional edgewise treatment and Implant-anchored orthodontics. Am J Orthod Dentofacial orthop. 2011; 139: 560-568.
45. Scheffler NR, Proffit WR, Phillips C. Outcomes and stability in patients with anterior open bite and long anterior face height treated with temporary anchorage devices and a maxillary intrusion splint. Am J Orthod Dentofacial Orthop. 2014; 146: 594-602.
46. Foot R, Gonzales C, Tarraf NE, Darendeliler MA. The short-term skeleto-dental effects of a new spring for the Intrusion of maxillary posterior teeth in open bite patients. Progress in Orthodontics (a Springer Open Journal). 2014; 15: 56.
47. Owman-Moll P, Kurol J, Lundgren D. Continuous versus Interrupted continuous orthodontic force related to early tooth movement and Root resorption. Angle Orthod. 1995; 65: 395-401.
48. Marek I, Tycova H, Baccetti. Molar Height and dentoalveolar compensation in adult subjects with skeletal open bite. Angle Orthod. 2011; 81 (4): 564-569.
49. Ng CST, Wong WKR, Hagg U. Orthodontic treatment of open bite. International J Paediatric Dent. 2008; 18: 78-83.
50. Reichert I, Figel P, Winchester L. Orthodontic treatment of anterior open bite: a review article- is Surgery always necessary?. Oral Maxillofac Surg J. 2014; 18:2 71-277.
51. Stellzig A, steegmayer- Gilde G, Basdara EK. Elastic activator for treatment of open bite. Br J Orthod. 1999; 26: 89-92.
52. Kuster R. Ingervall B. The effect treatment of skeletal open bite with two types of bite block. Eur J Orthod 1992; 14: 489-499.
53. Mavropoulos A, Bresin A, Slaveros K. Morphometric Analysis of the mandible in growing rats with different masticatory functional demands: Adaptation to an upper posterior bite block. Eur J Oral Sci. 2004; 112: 259-266.
54. Meibodi SE. Meybodi SARF, Samadi AH. The effect of posterior bite-plane on dentoskeletal changes in skeletal open-bite malocclusion. J Indian SOC Pedod Prev Dent. 2009; 27: 202-204.
55. Park HS, Kwon OW, Sung JH. Non-extraction treatment of an open bite with microscrew implant anchorage. Am J Orthod Dentofacial Orthop. 2006; 130: 391-402.
56. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intra-oral Anchorage. J Clin Orthod. 2003; 37: 321-328.
57. Kravitz N, Kusnofo B, Tsay T, Hohlt W. The use of temporary anchorage devices for molar intrusion. J Am Dent Assoc. 2007; 138: 56-64.
58. Kato S, Kato M. Intrusion of molars with implants as anchorage: a report of two Cases. Clin Implant Dent Rel Res. 2006; 8: 100-106.
59. Alrbata RH, Momani MQ, Al-Tarawneh AM, Ihyasat A. Optimal force magnitude loaded to orthodontic micro-implants: A finite element analysis. Angle Orthod. 2016; 86: 221-226.