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Evaluation of C-lingual retractor effects on anterior teeth using cone beam computed tomographic imaging

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Abstract
The purpose of this study was to analyze the en-masse retraction effects on the upper canines and incisors in Class II division 1 malocclusions using the C-lingual retractor appliance on these teeth by means of cone beam tomography imaging (CBCT).
The sample consisted of 12 patients aged between 18-25 years with Class II division 1 malocclusion collected from the department of Orthodontics and Orthopedics in Hama University. Average treatment period was 9 months. Pre- and post-treatment CBCTs were taken, and the related variables were compared.
Results: The current study showed significant retraction of the upper incisors using the C-Lingual Retractor Appliance with an average of (3.24 mm), with a vertical resorption of the alveolar crest with an average of (0.2 mm) from the labial aspect and (2.15 mm) from the palatal aspect, and a minimum root resorption of (1.58mm) in central incisors and (0.58 mm) in the canines, and a preferred torque control, where the average change of torque is (5.24°) in central incisors and (1.18°) in the canines, and a minimum loss of anchorage, with an average of (0.16mm) of upper first molar mesial drift.
Correction of Class II division 1 malocclusion using the C-lingual Retractor appliance can be achieved without any significant damage to the supporting alveolar bone or inducing any significant root Resorption with preferred Torque control of the incisors and minimal anchorage loss.

Keywords: Class II division 1, cone beam computed tomography, lingual orthodontics, C-lingual retractor

Introduction

Not so long ago, orthodontic treatment by the public and many orthodontists as well was seen as a treatment intended for children or a specific group of patients.
The decrease in the birth rate and the increase in the average age of the population in some countries have shifted the focus of many orthodontists to providing treatment to adults as well as children (Scuzzo, 2002) [12].
However, a significant number of these adult patients believe that traditional appliances are annoying or aesthetically unacceptable (Rosvall *et al*., 2009) [10] and thus have increased their desire for cosmetic solutions for poorly aligned teeth such as porcelain veneers, crowns, and other lab-made solutions. (Park *et al*., 2012) [9]
As a result, orthodontic appliances manufacturers tried to improve the cosmetic aspects of the appliances by providing brackets made of different materials such as ceramics (Scuzzo, 2002) [12] or plastic. These transparent brackets provided the cosmetic aspect, but they may irritate the soft tissues due to their large size.
As a result, Clear Aligners were introduced, they have the benefits of being hygienic and they insured the aesthetic appeal, but in orthodontics, the application of fine-tuned forces is essential to accomplish the final aligning of the teeth; One of the disadvantages of these devices is their inability to move the roots of the teeth efficiently, which results in a tilting movement of the teeth, especially in extraction cases (Park *et al*., 2012) [9] in addition of being heavily dependent on patient cooperation. (Boyd *et al*., 2000) [2]
The invisible (lingual) orthodontic appliance presented the best aesthetic solution for patients, without compromising the efficiency of biomechanical treatment.
(Scuzzo, 2002; Rosvall *et al*., 2009) [12, 10]
Traditional lingual treatment can complicate the torque control when the upper anterior teeth are retracted in patients with protrusion.

The C-lingual retractor appliance presented an alternative lingual method to obtain a controlled retraction force on the upper anterior teeth, as this appliance is an effective tool for achieving a translating movement during the retraction of the anterior teeth. (Chung *et al*., 2008) [3]

Heavy retraction forces of the anterior teeth in premolars extraction cases may result in some undesirable outcomes such as root resorption and loss of the alveolar bone at the lingual side of the upper incisors. Therefore, morphological evaluation of the alveolar bone and roots after en-mass retraction of the anterior teeth is a good model to indicate the limitation of the orthodontic movement. (Sarikaya *et al*., 2002; Ahn *et al*., 2013) [11, 1]

The aim of the research

Evaluation of en-mass retraction effects of anterior teeth in Class II division 1 malocclusion cases treated with the C-Lingual Retractor appliance with cone beam computerized tomography.

Materials and Methods

Sample description: The research sample consisted of CBCT images of 12 patients with class II division 1 malocclusion, before and after treatment with the C-lingual retractor appliance with extraction of the first upper premolars.

The sample was collected by returning to the patient records in the Department of Orthodontics and Orthopedics - University of Hama.

The inclusion criteria include patients between the ages of (18-25) years, with skeletal Class II relationship confirmed by measuring the angle (4 <ANB <10), dental Class II division 1 malocclusion requires extraction of the first upper premolars, and arch length discrepancy of no more than 3 mm.

The sample size was determined at 95% study strength and 0.05 significance level using the Gpower software, depending on the variable "The degree of root absorption" as a major variable in this study with a standard deviation equal to 0.68 taken from (Hwang *et al*., 2018) study which is similar to our study. We obtained a sample size of 10 patients, and by adding 20% withdrawal rate, the total number of sample individuals will be 12 patients.

Materials and devices used in the research

1. Cephalometric imaging device from Vatech, to perform a standard vertical profile image to confirm the skeletal malocclusion by measuring the ANB angle (4 <ANB <10) using WebCeph software.
2. CBCT imaging device from the Vatech, where the raw image data was processed and the DICOM files were extracted for each image, then the data was copied to the EZ 3D Plus program to facilitate the process of opening images and making linear and angular measurements before and after orthodontic treatment.

Research method

Patients suitable for conducting the study after clinical examination are referred to the radiography center to perform a CBCT image to obtain pre-treatment measurements (T0) and to select the appropriate lengths of screws to fix the skeletal anchorage miniplates at the center of the palate (Figure 1).

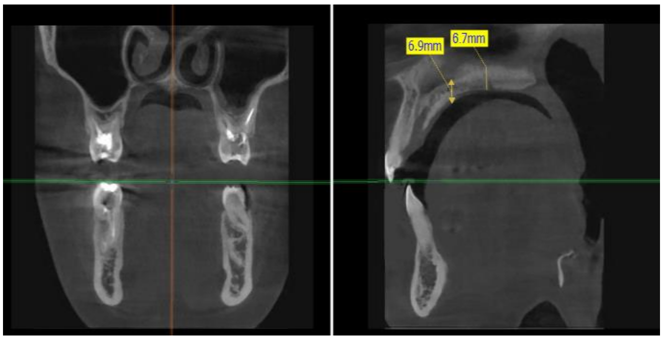

Fig 1: Determining the Length of the anchorage miniplate screws on the CBCT Image

Alginate impressions are taken for each patient prior to treatment to obtain the study and working models to manufacture of the C-Lingual Retractor appliance in the dental lab.

Surgical application of the skeletal anchorage miniplates in the center of the palate is done after adjusting the lateral hooks to fit the use of retraction coil-springs.

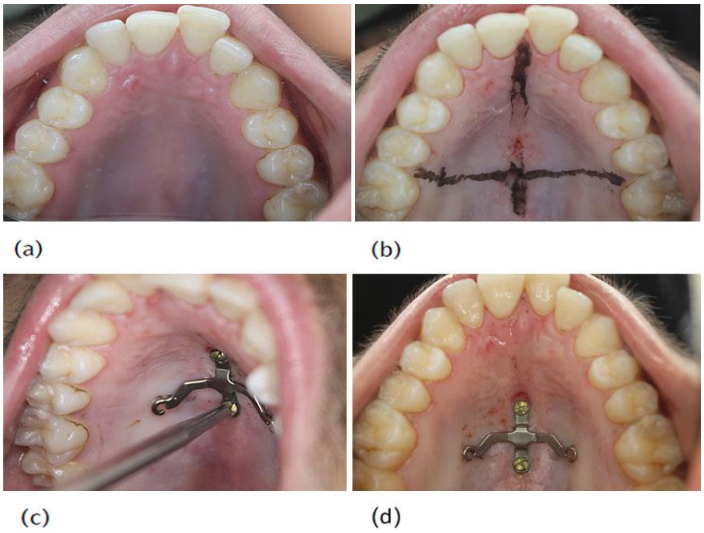

Fig 2: Fixing the skeletal anchorage miniplate in a closed method, (a) prior to surgery image, (b) drawing the location of the miniplate and marking of the bleeding points, (c) fixing the plate, (d) after fixing the miniplate

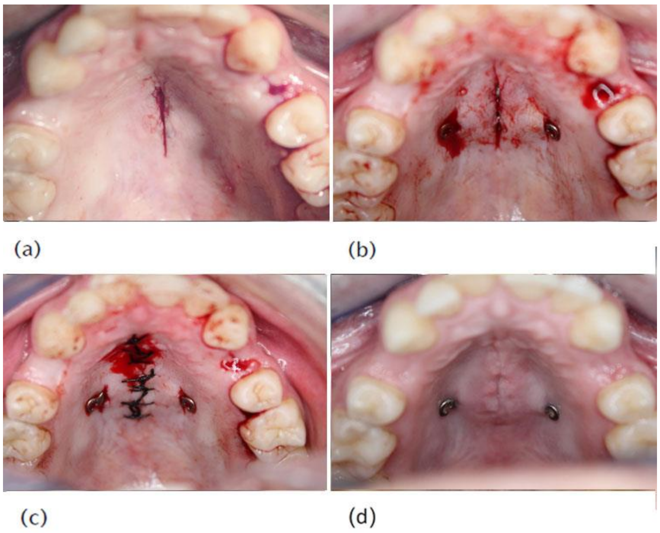

Fig 3: Stages of fixing the skeletal anchorage miniplate in the open method, (a) surgical incision procedure, (b) inserting the anchorage plate below the reflected flap, (c) suturing procedure, (d) removing the suture after a week

The orthodontic treatment is initiated with the first premolars extraction and the application of the C-lingual Retractor appliance, which consists of a stainless steel wire with a diameter of 0.032 inches welded on a mesh base bonded to the palatal surfaces of the upper anterior teeth with an orthodontic composite resin (BracePaste (American Orthodontics, Sheboygan, WI)), With two lever arms attached to the wire distal of the central incisors and two closed-coil springs made of nickel-titanium alloy are used as a source of orthodontic force. (Kim *et al*., 2003) [6]
These springs connects the lever arms with the skeletal anchorage plate, which is fixed on the center of the palate. (Chung *et al*., 2008) [3]
These springs are activated monthly until the completion of the retraction phase and the extraction spaces are fully closed, then the C-Lingual Retractor Appliance is left passive for three months for retention, then C-Lingual Retractor Appliance is removed, and the anchorage plate is removed and the patient is transferred to the radiography center to obtain a new post-treatment CBCT image (T1), these images are inserted into the EZ 3D Plus software to perform linear and angular measurements and to study the treatment outcomes.

Fig 4: C-Lingual Retractor Appliance

Measurements on CBCT
To obtain standard repeatable slides in all patients, CBCT images were reoriented:
1. The Axial plane has been oriented to adapt on the occlusion plane (OP), which connects the two mesial buccal cusps of the lower first molar and the contact point of the lower incisors (L1CP).
1. It was considered as a reference plane to perform angular measurements before and after treatment, as these points are not affected by the applied orthodontic forces.
2. The Frontal Plane is made perpendicular to the occlusion plane at (L1CP), and is considered a reference level for making some linear measurements.
3. The Sagittal Plane passes from (L1CP) and is parallel or applied to the maxillary midline that connects the Anterior Nasal Spine (ANS) and the Posterior Nasal Spine (PNS). (Suk *et al*., 2013) [13]

The sagittal plane is tilted to pass through the incisal edges and roots apices of the incisors and canines in order to perform linear and angular measurements on them.
(Table 1) shows the points used to make linear and angular measurements with the definition and abbreviation of each of them (Hwang *et al*., 2018)

Table 1: Names, definitions and abbreviation of the used points

Point	Definition
U1CP	Maxillary central incisor center of incisal edge point
U1RP	Maxillary central incisor root apex point
U3CP	Maxillary canine center of incisal edge point
U3RP	Maxillary canine root apex point
U6CP	Maxillary first molar mesial buccal cusp point

(Table-2) shows linear and angular measurements related to soft and dental tissues that were measured on CBCTs before and after treatment with the C-Lingual Retractor Appliance. (Hwang *et al*., 2018) [4]

Table 2: Linear and angular measurements

Labial vertical alveolar bone level (VABLL)	The distance from the cemento-enamel junction of the maxillary central incisor, to the summit of the buccal alveolar crest, in millimeters
Palatal vertical alveolar bone level (VABLP)	The distance from the cemento-enamel junction of the maxillary central incisor, to the summit of the palatal alveolar crest, in millimeters
Upper central incisor root length (U1RL)	The length of the maxillary central incisor is the line connecting the center point of the incisal edge of the maxillary central incisor (U1CP) to its root apex (U1RP) in millimeters.
Upper canine root length (U3RL)	The length of the maxillary canine is the line connecting the center point of the incisal edge of the maxillary canine (U3CP) to its root apex (U3RP) in millimeters.
Upper central incisor with the occlusion plane angle (U1-OP)	The angle formed between the line passing from incisal edge of the maxillary central incisor (U1CP) and its root apex (U1RP) and the occlusal plane (OP). measured in degrees.
Upper canine with the occlusion plane angle (U3 – OP)	The angle formed between the line passing from incisal edge of the maxillary canine (U3CP) and its root apex (U3RP) and the occlusal plane (OP). measured in degrees.
Upper first molar position (U6P)	The distance between the first molar mesial buccal cusp point (U6CP) and the frontal plane. In millimeters.
Overjet (OJ)	The horizontal distance between the incisal edge of the most prominent maxillary central incisor, to the incisal edge of the mandibular central incisor, in millimeters.

(Table 3) shows the study variables extracted from the linear and angular measurements studied in the previous table.

Table 3: Study variables pre and post treatment

Torque change of the maxillary central incisor (ΔU1-OP)	It is measured by calculating the difference between the angles of the maxillary central incisor axis and occlusal plane (U1 - OP) when measured before treatment (T0) and after treatment (T1).
Torque change of the maxillary canine (ΔU3-OP)	It is measured by calculating the difference between the angles of the maxillary canine axis and occlusal plane (U3 - OP) when measured before treatment (T0) and after treatment (T1).
Maxillary central incisor root resorption (U1RR)	It is measured by calculating the difference between the lengths of the maxillary central incisor (U1RL) when measured before treatment (T0) and after treatment (T1).
Maxillary canine root resorption (U3RR)	It is measured by calculating the difference between the maxillary canine root length (U3RL) when measured before treatment (T0) and after treatment (T1).
Labial alveolar process change (ΔVAPLL)	It is measured by calculating the difference between the levels of the labial alveolar bone (VAPLL) when measured before treatment (T0) and after treatment (T1).
Palatal alveolar process change (ΔVAPLP)	It is measured by calculating the difference between the levels of the palatal alveolar bone (VAPLP) when measured before treatment (T0) and after treatment (T1).
Anchorage Loss (AL)	It is measured by calculating the difference between the maxillary first molar distance from the frontal plane (U6P) when measured before treatment (T0) and after treatment (T1).
Retraction amount (Overjet change) (ΔOJ)	The difference between the overjet value (OJ) when measured before treatment (T0) and after treatment (T1).

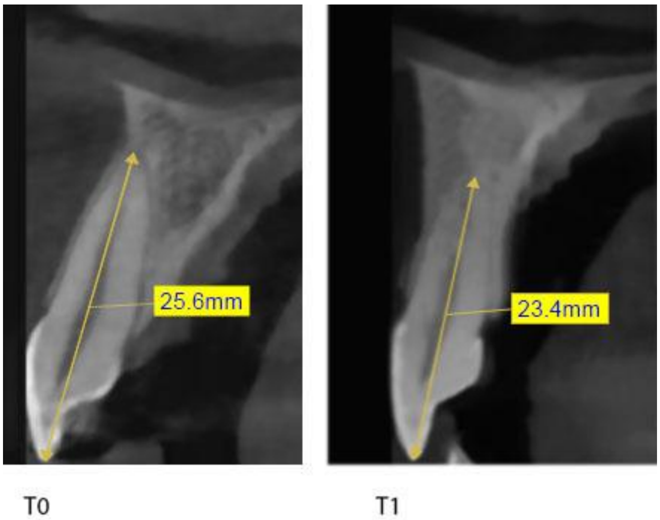

Fig 5: U1RR maxillary central incisor root length: (T0) before retraction, (T1) after retraction

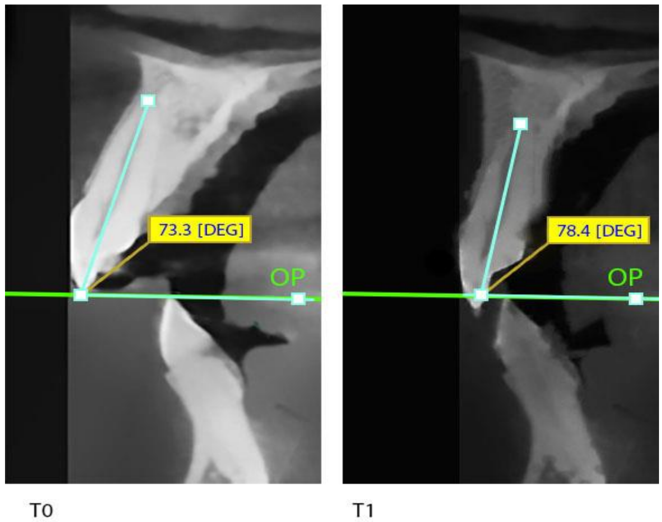

Fig 6: Maxillary central incisor's axis angle with the occlusion plane U1-OP: (T0) before retraction, (T1) after retraction

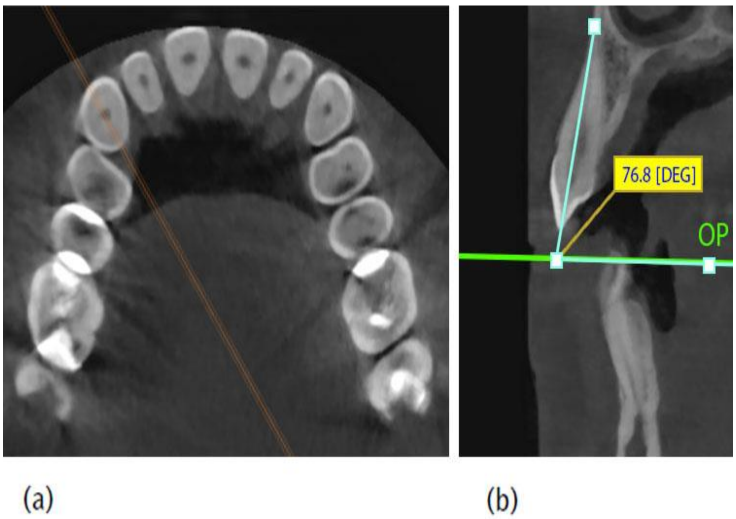

Fig 7: Maxillary canine's axis angle with the occlusion plane U3-OP: (a) Determination of buccal-palatal axis, (b) Measurement of the canine longitudinal axis angle with the occlusion plane

Results

The table below shows the results of the t-test for the correlated samples to study the significance of differences in the mean of the study variables.

Table 4: Shows the results of the t-test to study the significance of the differences in the mean of the studied variables.

Variable	T value	P value	Mean difference	Standard deviation	Confidence interval 95%	
					Minimum limit	Maximum limit
ΔVAPLL	9.381	0.000	0.20	0.07	0.15	0.25
ΔVAPLP	31.121	0.000	2.15	0.24	2.00	2.30
U1RR	6.838	0.000	1.58	0.80	*0.72*	2.32
U3RR	10.383	0.000	0.58	0.19	0.46	0.71
ΔU1-OP	14.619	0.000	5.24	1.24	4.45	6.03
ΔU3-OP	-4.875	0.000	1.18	0.84	0.65	1.72
AL	7.467	0.000	0.35	0.16	0.25	0.45
ΔOJ	19.235	0.000	3.24	0.58	2.87	3.61

From the table, we note that the value of the significance level is less than the value (0.05) for all study variables, that is, at the 95% confidence level there are statistically significant differences in the mean of all the mentioned variables.

Discussion

Alveolar bone resorption

The average amount of alveolar resorption of the maxillary right central incisor of the labial aspect was 0.2 mm and of the palatal aspect was 2.15 mm.

The results of our study were consistent with the study of Huang *et al*. (Hwang *et al*., 2018) [4] that is similar to our study at a 95% confidence domain in the resorption of alveolar crest from the vestibular aspect (0.16 mm) and from the palatal aspect (2.37 mm) at a 95% confidence interval.

The results of our study differed with the study of Ahn (Ahn *et al*., 2013) [1] who studied the resorption of alveolar bone after en-mass retraction using the traditional buccal appliance, where the mean resorption of the labial aspect (0.2 mm) and the palatal aspect (3.65 mm) at a confidence interval of 95%.

This can be due to the length of treatment duration in cases treated with the traditional appliance because of the leveling and aligning phase before the retraction phase.

Root resorption

Average lengths of central incisors and canines were 24.95 mm and 27.1 mm respectively prior to treatment (t0), and the Average root resorption in our study was 1.58 mm (6.33%) and 0.58 mm (2.14%) for both centrals and canines, respectively.

The results of our study were consistent with the study of Huang *et al*. (Hwang *et al*., 2018) [4] similar to our study at 95% confidence interval, where the apical resorption resulting from the en-mass retraction in the C-Lingual retractor appliance in the root of the central incisors in their study was (0.8 mm) 3.38%.

Whereas when treating with buccal traditional appliance according to Liou and Chang study (Liou and Chang, 2010) [8] who studied resorption due to the miniscrews-anchoraged en-mass retraction, the apical resorption reached 2.5 mm (16%) of the central incisor length.

This can be due to the length of treatment duration in the cases treated with the traditional appliance because of the levelling and alignment phase before the retraction phase.

Torque Control

The mean of the change of the torque of the central incisor was 5.24°, and the mean of the change of the torque of the canine was 1.18 °.

In our study we agreed with the study of Kim and his colleagues (Kim *et al*., 2011) [5], who studied the effects of C-Lingual Retractor appliance on the anterior teeth; The change in the torque of the central incisor was 6.2° within 95% confidence interval.

We differed in our study with that of Huang and his colleagues (Hwang *et al*., 2018) [4], where the change in the angle of the upper canine axis with the occlusal plane (torque) reached 5.61° within 95% confidence interval.

This difference can be due to the method of establishing the occlusal plane in Huang's study, where it was established using three points: the center of the incisal edge of the upper central and the mesial buccal cusp of the maxillary first molar on both sides, while in our study we adopted the occlusal plane that connects the middle buccal cusp of the mandibular first molars and the contact point of the mandibular incisors, in order to ensure the relative stability of the occlusal plane during the treatment stages.

Anchorage loss

The mean of anchorage loss, i.e., the amount of maxillary first molar mesialisation toward the frontal plane was 0.35 mm.

We agreed with our study with Huang's study (Hwang *et al*., 2018) [4], where the anchorage loss amounted to 0.43 mm after retraction using the C-Lingual Retractor within a 95% confidence interval.

Whereas, the loss of the anchorage in the traditional fixed buccal appliance was 1.3mm when using miniscrews as skeletal anchorage devices, and 1.4 mm when using miniplates as skeletal anchoring devices, and 2.5 mm when using the headgear and a TPA according to a study (Lai *et al*., 2008) [7]

Amount of retraction (change in Overjet)

The mean of the anterior teeth retraction distance was 3.24mm in our study, where the pre-treatment (T0) overjet was (5.30 mm) and after treatment (T1) was (2.20 mm).

We agreed with our study with Huang *et al*. (Hwang *et al*., 2018) [4], where they retracted the anterior teeth 3.6 mm using the C-Lingual Retractor within a 95% confidence interval.

Conclusions

1. The measurements on CBCT images by comparison between the T0 and T1 treatment periods showed significant differences when studying all study variables (the amount of incisor retraction or the change in overjet, torque change for both the central incisor and the canine, the amount of the first molar mesialisation, alveolar process Resorption from the labial and palatal aspect, and the root Resorption.
2. The C-lingual Retractor appliance is a useful method to retract the anterior teeth with excellent avoidance of the side effects of the retraction as it leads to a minimum induction of root resorption, resorption of labial and palatal alveolar bone and anchorage loss compared to the traditional orthodontic appliance at the 95% confidence interval.

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