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Evaluation of anchorage loss of the upper first molar using two different retraction methods: A randomized clinical trials

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Objective: *the aim of the present study was to evaluate the anchorage loss of the molar using two different retraction methods.* ***Subjects and methods****: The current randomized controlled clinical trials were conducted on a total sample of 10 orthodontic patients (3 males and 7 females), a split- mouth design was performed. Two main groups, which group I included a procedure of canine retraction by using sectional arch in the conventional level of the brackets and tubes, while group II included a procedure of canine retraction through sectional arch in high position utilizing power arms attached to canine and molar tubes. A cone beam computed tomography had been used as observational method.* ***Results:*** *The results showed a significant increase in the anchorage loss in both of the groups, however no significant statistical difference between the two groups.*

Conclusion*: It concluded that both techniques seem to have loss in the anchorage, however comparing both groups with each other's seems to show no significant differences.*

Introduction

The malocclusion considered to be a disturbed relationship between the maxilla and mandible, and due to the high increase in its prevalence it became a growing public health problem.[1] The definition of orthodontic anchorage is providing a resistance to counteract and prevent the unwanted tooth movement, there are multiple methods to provide an anchorage during orthodontic treatment such as the using of headgear, face mask, and transpalatal arch.[2]

The control of the anchorage seems to be so essential for orthodontic treatment.[3] The type of malocclusion that is caused by the protrusion of dentoalveolar seems to be hard to be treated, hence this is required a solution by using the concept of absolute anchorage to counteract the undesirable mesial movement of the posterior teeth which is very harming for the treatment results.[2]

The idea of increasing the use of sliding mechanics in orthodontic treatment open a window of research interest in this field, which, as a frictional force will be formed between the brackets and orthodontic arch-wire, as this force may prevent tooth movement, demanding higher forces and affect the anchorage badly, also the magnitude, control and clinical significance of this frictional resistance are greatly

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unknown.[4]

The segmented arch mechanics seems to have a proper control on tooth movement if it compared to arch-wire guided tooth movement, as it suggests dividing the dental arch into three main parts, as this technique aimed at reducing the posterior teeth forward-movement.[5]

Multiple studies [5-9] had discussed the anchorage loss and its effect on orthodontic treatment. Consequently, in this study, it aimed to understand and evaluate the anchorage loss of the molar using cone beam computed tomography (cbct).

Materials and methods

The current randomized controlled clinical study was conducted on a total sample of 10 orthodontic patients (3 males and 7 females) 6 patients were having class I bimaxillary protrusion and 4 patients were having class II division one, complaining of protrusion and requiring upper first premolar extraction as part of their orthodontic treatment plan, the sample size calculation done according to a previous study[10]. The samples included the patients who visited orthodontic clinic of faculty of dentistry of Alasmarya Islamic University. The patient's age ranged between (14-21) years. A Split- mouth design with a random allocation was applied in the study. In this split- mouth design, the study conducted on two groups which randomly allocated by simple online generated randomization plan using online software found at this website: https://www.graphpad.com . the randomization was to determine which side will have a certain technique, the right and left sides. Group I: The canine retracted by sectional arch in the conventional level of the brackets and tubes. Group II: The canine retracted by sectional arch in high position utilizing power arms attached to canine and molar tubes.

The ethical consideration had obtained from ethical committee of Faculty of Dentistry, Alasmarya Islamic University. The inclusion criteria included:

1. Treatment plans that including extraction upper first premolars and applying a canine retraction.
2. Patients who own an Excessive overjet and /or bimaxillary protrusion.
3. Fully erupted permeant dentitions.
4. The canines should be healthy, and sound.
5. Patient should be free of any periodontal diseases.
6. Good oral hygiene and general health.
7. The patient should be free of any type of systemic diseases that may interfere with orthodontic tooth movement.
8. The patient should be free of any type of medication that may interfere with orthodontic tooth movement.

The Orthodontic treatment could be terminated after given two notices to the patient's side under the following conditions which could affect seriously the progress of treatment:

a. Frequent broken appointments (more than three times).

b. Frequent broken orthodontic appliance.

c. Failure to keep good standard of oral hygiene.

A thorough clinical examination and a detailed clinical diagnostic chart were completed for each patient. The following diagnostic records were taken for each patient before and after treatment:

1- Orthodontic study casts.

2- Standardized lateral cephalometric radiograph.

3- Digital panoramic radiograph.

However, the intra and extra-oral photographs done before, during and after orthodontic treatment, and before and after canine retraction. Also, the cbct done before and immediately after canine retraction.

The study was conducted by using a split-mouth design, therefore the canine on one side was retracted by sectional arch in the conventional level of the brackets and tubes. The canine on the other side was retracted by sectional arch in high position utilizing power arms attached to canine brackets and molar tubes. An appropriate readymade Bands (Molar Band, American orthodontics, USA.) were selected for the maxillary first molars, and Custom-made bands were fabricated for each maxillary canine. A weldable intraoral double molar tube (Buccal Tube, American orthodontics, USA.) was welded (Dentaurum Assistent Welder,Germany.) on the middle third of the buccal surface of the canine band on the side of the power arm and weldable intraoral single tube was welded on the other side. Intraoral double tubes were aligned horizontally and welded on power arms of maxillary canine and first molar. On power arm side, the length of canine and first molar were assessed through CBCT to determined center of resistance (CR). The center of resistance of canine is located at 42% of the root length when measured from alveolar crest while the center resistance of first molar is located at 1or 2 mm apical to furcation area.

Accordingly, the power arm vertical level for canine is determined through the following steps:

1. The total length (apex- tip) is assessed through CBCT.

2. The distance from apex to alveolar crest is measured through CBCT and 42% is calculated to determine the center of resistance of canine.

3. The distance from cusp tip to alveolar crest measured through CBCT.

4. The distance from cusp tip to center of resistance calculated by adding the distance from alveolar crest to the center of resistance to the distance from cusp tip to alveolar crest.

5. The distance from cusp tip to center of intraoral tube measured clinically.

6. The vertical length of power arm determined by deducting the determined distance in step (d) from the determined distance in step (e).

The power arm vertical level for first molar determined through the following steps:

1- The distance from central fossa to a point located 1 or 2 mm apical to furcation area measured through CBCT.

2- The distance from cusp tip to center of intraoral tube measured clinically.

3- The vertical length of power arm determined by deducting the determined distance in step (a) from the determined distance in step (b).

Canine Retraction:

1- The right and left canines were retracted distally at the same time after two weeks healing period after premolar extraction in all cases using sectional 0.016 X 0.022-inch stainless steel (Stainless Steel arch wire, American orthodontics, USA) modified delta closing loop (Fig.1). 2- The loop on the side of the power arm was inverted, the base toward mucogingival junction to avoid ulceration and irritation.

3- The loop was inserted into canines and molars tubes.

4- The canines were retracted distally using a force 150g. The force was calibrated using a tension gauge (Ormco, Company, USA.

Figure (1): Canine retraction using sectional closing loop. (a) Sectional arch in the conventional level of brackets and tubes, (b) Sectional arch in high position utilizing power arm attached canine and first molar

Observational methods:

All patients submitted for CBCT for evaluation. CBCT images were acquired using a Planmeca Promax Mid machine (Planmeca. Helsinki, Finland.). A scout view was obtained, and adjustments were made to ensure that all patients were correctly aligned in the scanner according to adjustment light beam before acquisition. The machine is operating at the following protocol for all the scans of the study:

Table (1): CBCT machine followed protocol

Tube voltage	85 KVp
Milliampere	15 MAs
Voxel size	133 Um
Scanning time	18 Seconds
Field of view	7.5 cm x 10 cm x 10cm.

After acquisition, data were exported and transferred in DICOM format and downloaded via a Compact Disk (CD) to a personal computer for linear and angular measurements using Invivo Dental software (Anatomage, San Joes, CA.). Serial of steps were followed to standardize the measurements in all scans.

First, superimposition, the set of Dicom data of the preoperative scan is loaded into the software, and then the set of the postoperative scan of the same patient was loaded over it. According to variation in positioning of both scans, a second adjustment was needed to ensure perfect superimposition, hence guaranteeing measuring linear and angular measurements at the exact level. Superimposition module was used to superimpose the postoperative scan over the preoperative one, where four landmarks at different anatomical areas were chosen at each scan, and then registration of these landmarks was automatically performed by the software. Superimposition sequence was repeated for each patient individually.

Second, Orientation; certain planes were to be assigned, according to which the measurements would be taken. After completion of superimposition, the two scans (preoperative and postoperative were one unit and move in the same sequence. Orientation of the whole volume was made to ensure that the orthogonal reference lines (axial, coronal and sagittal) were following certain planes. The idea of orthogonal reference lines depends on three lines in three different directions and always perpendicular to each other. Reconstruction of certain planes dictated alignment of these three lines according to certain anatomical landmarks. At section module, axial reference line was viewed at the sagittal plane and it was made passing through ANS (anterior nasal spine) and PNS (posterior nasal spine), this orientation controlled volume antero-posterior orientation. At the axial view, two lines were present; sagittal and coronal reference lines. In order to assign maxillary plane, three points were identified at the level of the hard palate; ANS anteriorly, right and left posterior maxillary points.

The coronal line was adjusted to pass through PMPr (posterior maxillary point right) and PMPl (posterior maxillary point left), and sagittal line passed through ANS and PNS (Fig. 2).

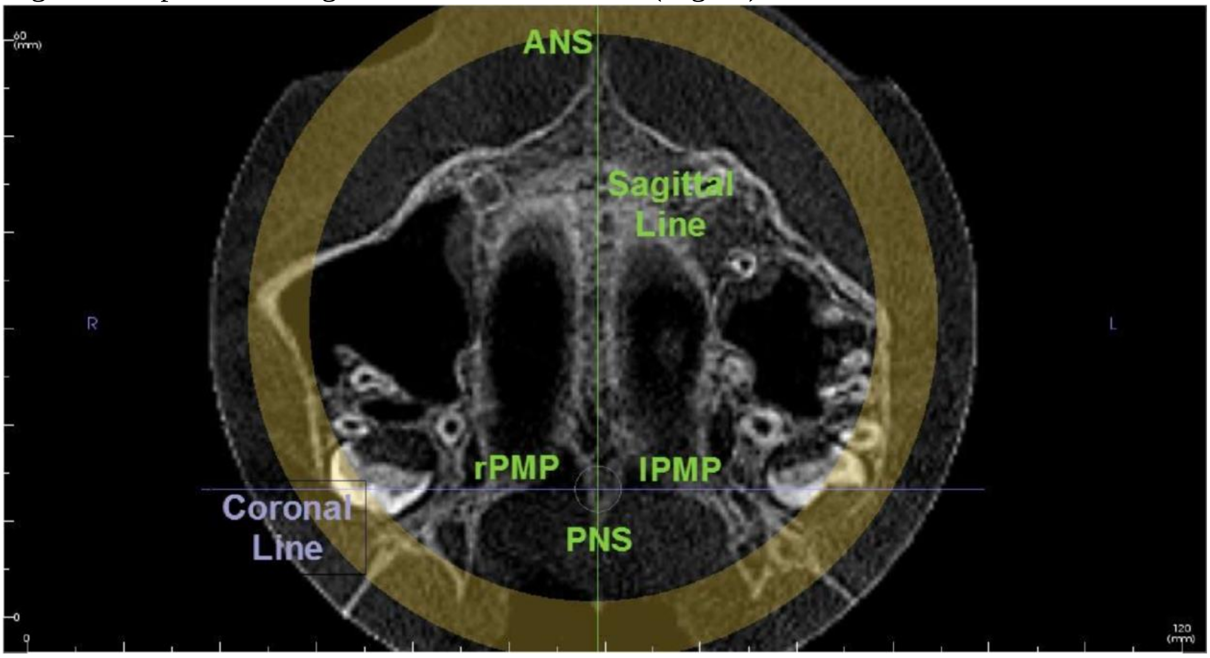

Figure (2): Sagittal and coronal reference lines to assign maxillary plane at axial view.

At that orientation, we obtained the following views

a. Axial view; representing maxillary plane (ANS, PMPr and PMPl)

b. Sagittal view; representing the mid-sagittal plane (ANS and PNS) and perpendicular to maxillary plane

c. Coronal view; representing a plane passing though PMPr and PMPl and perpendicular to maxillary plane and mid-sagittal plane as well.

Changing the level of the viewed section at axial, coronal or sagittal plane, would not change these relations since the orientation of the volume data was saved.

Measurements:

First the preoperative scan was highlighted, and at the sagittal view, the anchorage loss was assessed through linear and angular measurements. Coronal line (represent maxillary plane perpendicular passing through PMPr- PMPl) was assigned as a reference for measurement of antero-posterior linear distances. For measurement, on the sagittal view, the horizontal distance from mesio-buccal cusp tip to the coronal line was measured along a line parallel to maxillary plane. Also, similar measurement was taken at the apex of the mesio-buccal root. Molar angulation was measured as the angle between the line passing through mesio-buccal cusp tip and mesio-buccal root apex and the maxillary plane (Fig.3). After taking these measurements, preoperative scan was hidden, and the post-operative scan was highlighted and the same measurements were taken in relation the same reference lines. For bucco-palatal inclination, coronal view was assigned, where coronal reference was temporarily moved to the level of first molar, and at the produced view, an angle was measured between the line passing through mesio-buccal cusp tip and mesio-buccal root apex and another line representing the maxillary plane. After taking that measurement, the coronal line was restored to its original position.

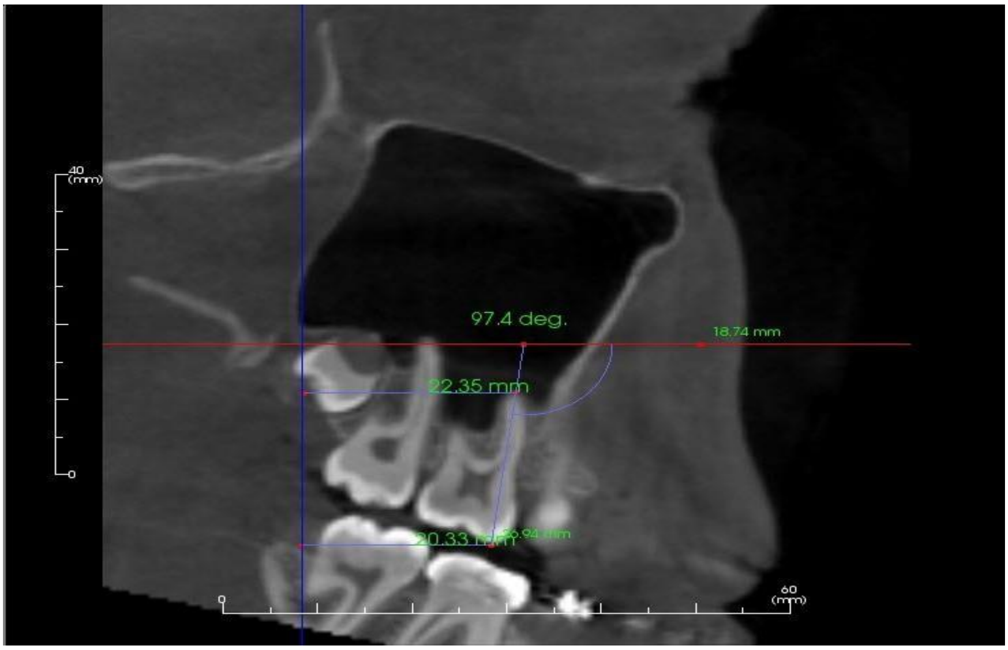

Figure (3): Maxillay first molar measurements at sagittal view.

Results:

Numerical data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests. All data showed normal (parametric) distribution. Data were presented as mean and standard deviation (SD) values. Repeated measures ANOVA test was used to study the changes by time within each group as well as to compare between the two groups. Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. Paired t-test was used to compare between the amounts of change in all measurements in the two groups. The significance level was set at P $\leq$ 0.05. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. Also, the high level stand for the group that's using power arm, while the low level stand for the group that using conventional method, without using a power arm in the upcoming tables.

Table (2): Demographic distribution of gender.

Gender	Frequency	Percentage
Male	3	30.0
Females	7	70.0
Total	10	100.0

Table (3): Demographic distribution of Age.

Age	Frequency	Percentage
14.00	1	10.0
15.50	1	10.0
16.00	1	10.0
17.00	2	20.0
18.00	2	20.0
19.00	1	10.0
20.00	1	10.0
21.00	1	10.0
Total	10	100.0

A. Anchorage Loss (mm)

1. The distance between the cusp tip of the mesio-buccal cusp of maxillary first molar right or left (U6MBCTr - U6MBCTl) and coronal plane (CP) in sagittal section in millimeter.

<u>Changes within each group</u>

In both groups; there was a statistically significant increase in U6MBCT - CP measurement post-treatment (*P*-value <0.001, Effect size = 0.943) and (*P*-value <0.001, Effect size = 0.953), respectively.

Table (4): Mean, standard deviation values and results of repeated measures ANOVA test for the changes in U6MBCT - CP measurement within each group

Group	Pre-treatment		Post-treatment		*P*-value	*Effect size (Partial Eta Squared)*
	Mean	SD	Mean	SD		
High level	19.1	2.17	20.81	2.31	<0.001*	0.943
Low level	19.81	1.65	21.53	1.78	<0.001*	0.953

*: *Significant at P ≤ 0.05*

<u>Comparison between the two groups</u>

Either pre- or post-treatment, there was no statistically significant difference between mean U6MBCT - CP measurements in the two groups (*P*-value = 0.210, Effect size = 0.169) and (*P*-value = 0.274, Effect size = 0.131), respectively.

There was no statistically significant difference between mean increase in U6MBCT - CP measurements in the two groups (*P*-value = 0.082, Effect size = 0.510).

Table (5): Mean, standard deviation values and results of repeated measures ANOVA test for comparison between U6MBCT - CP measurement in the two groups and paired t-test for comparison between changes in the two groups

Time	High level		Low level		*P*-value	*Effect size*
	Mean	SD	Mean	SD		
Pre-treatment	19.1	2.17	19.81	1.65	0.210	*Partial Eta Squared* = 0.169
Post-treatment	20.81	2.31	21.53	1.78	0.274	*Partial Eta Squared* = 0.131
Change	1.91	0.32	1.72	0.4	0.082	*d =0.510*

*: *Significant at $P \leq 0.05$*

2. The distance between the midpoint on the apex of the mesio-buccal root of maxillary first molar right or left (U6MBRAr - U6MBRAl) and coronal plane (CP) in sagittal section in millimeters.

<u>Changes within each group</u>

In both groups, there was a statistically significant decrease in U6MBRA - CP measurement post-treatment (*P*-value <0.001, Effect size = 0.897) and (*P*-value <0.001, Effect size = 0.812), respectively.

Table (6): Mean, standard deviation values and results of repeated measures ANOVA test for the changes in U6MBRA - CP measurement within each group

Group	Pre-treatment		Post-treatment		*P*-value	
	Mean	SD	Mean	SD		*Effect size (Partial Eta Squared)*
High level	22.86	1.85	20.51	1.53	<0.001*	0.897
Low level	22.93	1.45	20.96	1.47	<0.001*	0.812

*: *Significant at $P \leq 0.05$*

Comparison between the two groups

Either pre- or post-treatment, there was no statistically significant difference between mean U6MBRA - CP measurements in the two groups (*P*-value = 0.889, Effect size = 0.002) and (*P*-value = 0.274, Effect size = 0.131), respectively.

There was no statistically significant difference between mean decrease in U6MBRA - CP measurements in the two groups (*P*-value = 0.414, Effect size = 0.378).

Table (7): Mean, standard deviation values and results of repeated measures ANOVA test for comparison between U6MBRA - CP measurement in the two groups and paired t-test for comparison between changes in the two groups

Time	High level		Low level		*P*-value	*Effect size*
	Mean	SD	Mean	SD		
Pre-treatment	22.86	1.85	22.93	1.45	0.889	*Partial Eta Squared* = 0.002
Post-treatment	20.51	1.53	20.96	1.47	0.274	*Partial Eta Squared* = 0.131
Change	-2.35	0.84	-2.03	0.86	0.414	*d =0.378*

*: *Significant at P ≤ 0.05*

B. Molar angulation (º)
Changes within each group

In both groups; there was a statistically significant increase in molar angulation measurement post-treatment (*P*-value <0.001, Effect size = 0.898) and (*P*-value <0.001, Effect size = 0.918), respectively.

Table (8): Mean, standard deviation values and results of repeated measures ANOVA test for the changes in molar angulation measurement within each group

Group	Pre-treatment		Post-treatment		*P*-value	*Effect size (Partial Eta Squared)*
	Mean	SD	Mean	SD		
High level	85.36	6.17	88.59	6.11	<0.001*	0.898
Low level	84.85	4.96	88.47	5.14	<0.001*	0.918

*: *Significant at P ≤ 0.05*

Comparison between the two groups

Either pre- or post-treatment, there was no statistically significant difference between mean molar angulation measurements in the two groups (*P*-value = 0.570, Effect size = 0.037) and (*P*value = 0.916, Effect size = 0.001), respectively.

There was no statistically significant difference between mean increase in molar angulation measurements in the two groups (*P*-value = 0.423, Effect size = 0.229).

Table (9): Mean, standard deviation values and results of repeated measures ANOVA test for comparison between molar angulation measurement in the two groups and paired t-test for comparison between changes in the two groups

Time	Mean	SD	Mean	SD		
Pre-treatment	85.36	6.17	84.85	4.96	0.570	*Partial Eta Squared* = 0.037
Post-treatment	88.59	6.11	88.47	5.14	0.916	*Partial Eta Squared* = 0.001
Change	3.23	1.15	3.62	1.14	0.423	*d =0.229*

**: Significant at P ≤ 0.05*

Discussion:

The present study focused on evaluation the anchorage loss that may occur in the molars during retraction of the canine, in addition to form an assessment for the molar inclination and angulation to create an understating about what will happen to the molar during retraction procedure. The results of the present study showed that in both groups there was a statistically significant increase in U6MBCT - CP measurement post-treatment, despite that results, the comparison between the two groups either pre- or post-treatment, there was no statistically significant difference between the mean of U6MBCT - CP measurements in the two groups, which this is indicate that both groups serve the same results statistically.

Mufide Dinger et al.[11] performed a study in 1994 to create a comparison for the effects of Gjessing's canine retraction arch with a sectional arch including a reverse closing loop, which are both used for canine retraction in extraction cases. They found that there is an anchorage loss in both groups, the average anchorage loss was 1.63 mm at the Gjessing retraction arch side and 2.46 mm at the reverse closing loop arch side. Well, these results come in agreement with the findings of the present study, as its results showed that there is an anchorage loss in both U6MBRA-CP and U6MBCT-CP. Mufide Dinger et al. stated that the difference between the groups was significant, this is also come in disagreement with the findings of the present study, as it showed that there is not statistically difference between both groups. P Ziegler et al.[12] in 1989 performed a clinical study that included the retraction of maxillary canines. They found that in most cases there was a slight mesial movement of the first molars (anchorage loss). The average anchorage loss was 0.4 mm on the side with the sliding mechanics and 0.6 mm on the side with a retraction spring. Well, these findings come in agreement with findings that the present study showed.

Darendeliler MA et al.[13] performed a study to try the clinical application of the forces of drum spring (DS) retractor, and to compare its effect with forces produced by a traditional pull coil (PC) retractor system on the rate of upper canine retraction. They found that both systems demonstrated significant anchorage loss, also no difference was observed between the DS and PC sides. These findings come in agreement with the findings of the present study.

The type of anchorage that's used in the present study depend on the concept of the root surface of the molar in comparing to canine, without using any type of absolute or extra-oral anchorage. Adel Alhadlaqa et al.[14] evaluate the anchorage condition during canine retraction with using transpalatal arch with continuous and segmented arch mechanics. They found that " The molar relationship has become more class II in the continuous arch group compared with the segmented arch group due to the forward movement of the upper molars (loss of anchorage). Also, the Frankfurt-Mandibular plane angle (FMA) showed a greater increase after canine retraction in the continuous arch group than in the segmented arch group, but the difference was not statistically significant. There was no other significant difference between the two groups.", well these findings confirmed that there is an anchorage loss in both of the groups, which this is come in agreement with findings of the present study. Also came in agreement with the findings of Işik Aslan et al.[15], as they stated that there is an anchorage loss happened in their groups.

Multiple studies[15-21] focused in understanding and evaluating the anchorage loss in orthodontics, but it's so difficult to have a comparison between its results and the findings of the present study due to multiple factors such as differences in methodology and study design, in addition to observational methods.

Conclusion: The present study concluded that there is not statistically difference in the anchorage loss between conventional and high-level method, as both of them showed a significance loss of anchorage.

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