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Evaluation of Torque Changes in Buccal Segment Using Two Methods of Anterior Retraction

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Abstract: Aim: The study was to evaluate of torque changes in buccal segment using two methods of anterior retraction **Materials and methods:** Twenty patients complaining from flaring in the maxillary anterior teeth were examined by cone beam computed tomographic radiographs and all cases indicated for first premolars extraction. Half of them had been treated with (0.017 × 0.025 inches) preformed reverse curve TMA with closing (T-loop) and the other half had been treated with Torqueing spring as an auxiliary spring under the main arch-wire together with continuous power chain for retraction of the upper anterior teeth. The pre and post CBCTs were analyzed three dimensionally using the image processing method (**Mimics Innovation)**. Angular measurements for the maxillary buccal segment were taken to evaluate the changes of torque in posterior teeth during retraction. **Results:** There is statistically insignificant difference between buccal segment torque during anterior retraction in each group using closing loop or torqueing spring but there are statistically significant differences between buccal segment torque in closing loop and torqueing spring. **Conclusion:** Using of torqueing spring appliance affect the torque value on the buccal segment than the TMA closing preformed (T-loop).
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Keywords: Evaluation; Torque; Change; Buccal Segment; Method; Anterior Retraction

1. Introduction:

Axial inclination of teeth at the end of orthodontic treatment is considered one of the criteria for obtaining a functional occlusion and considered one of the important considerations in the successful treatment of malocclusion, which is principally significant in creating of proper anterior guidance, an esthetic smile line, and a firm Class I relationship[1].

This interaction produces a couple at the bracket interface. It describes rotation around x-axis. This could be generated by a rotation through a moment or couple of forces[2]. Torsional play or engagement angle may happen when lack of cohesion contact between brackets and engaged wire due to use of less dimension arch wire in bracket slot[3]. So, there are two methods of applying extra torqueing force in orthodontic appliance. First is rectangular arch wire snugly fitting in edgewise bracket slot. Second, are auxiliaries applying direct force to the tooth or group of teeth.

Retraction of anterior segment in extraction cases is considered one of the most challenging processes in orthodontic treatment, as it needs a solid grasp of biomechanics with the purpose of keep away from adverse angulations either in anterior or posterior segments. Anterior segment retraction can be done through sliding or frictionless procedures and each method has its maneuvers with possible side effects[4]. Friction or sliding procedure is more smart due to its simplicity and control ability as the brackets slide on the orthodontic archwire with definite torque and angulation.

In contrast, frictionless method uses preformed loop bends to create power to close up the gap location with build in torque permitting disparity moments in the reactive and active units. This leads to a small or high anchorage control in buccal segment, basing on the technique of retraction either one-step (en-mass) or two steps retraction technique[5].

However, in both techniques adjusting the facio-lingual inclinations is one of the goals that have to be achieved i.e. torquing adjustment and controlling the anchorage unit is very important issue to prevent any anchorage loss in buccal segment that may result change the proper angulation of posterior teeth and insufficient retraction of anterior segment. Accordingly, this study was conducted to compare between the changes of buccal segment torque while using two different mechanics of anterior retraction.

2. Materials and methods

The study was carried out on 20 patients, who were selected from the outpatient clinic of the Department of Orthodontics, Faculty of Dentistry, Minia University.

All selected patients had medically free from any systemic diseases with good oral hygiene and no gingival inflammation nor periodontal pocketing to ensure that the bone support is not jeopardized. The age sample is not less than 12 years old with full permanent dentition. All cases had to show space discrepancy not less than 6 mm per arch to be indicated for premolar extraction as the lateral cephalometric x-rays had to show flaring of the upper anterior teeth that required extraction of upper premolars.

Ethical regulations:

Before starting the study, approval of the committee of ethics in the faculty was taken to conduct this research. And all patients were informed about the procedures and an informed consent was signed by the patient parents. For patients under the age of 21 years a verbal approval was taken.

All cases were planned to be treated using fixed appliance using metal brackets with Roth prescription and 0.022 x 0.028-inch slot size.

Patients were randomly divided into 2 groups (10 each):

Group A:

Patients of this group were treated using the preformed (0.017 × 0.025 inches) reverse curve TMA closing preformed (T-loop) "Ormco TMA T -loop" for retraction of the upper incisors Fig (1).

Fig. (1): TMA T-Loop

Group B:

Patients of this group were treated using Torquing spring "ART Auxiliary (Anterior Root Torque appliance) as a preformed auxiliary spring under the main arch-wire together with continuous power chain for retraction of the upper anterior teeth. Fig (2,3).

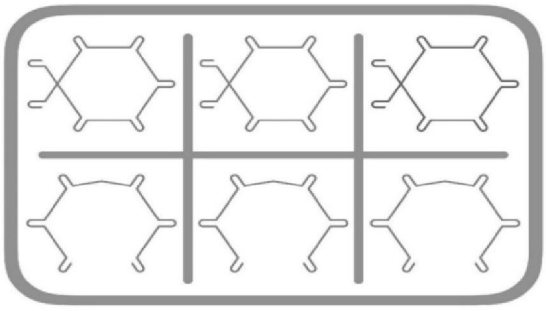

Fig. (2) Clinical design of torquing spring.

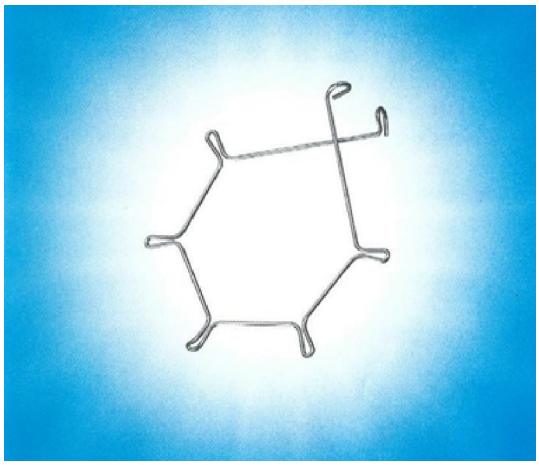

Fig. (3) schematic design of torquing spring.

Banding and bonding were carried out using (ROTH metal brackets system)**.** After complete retraction of the canine with proper contact with the second premolar, (0.019×0.025) inch stainless steel rectangular arch wire was inserted and left in place for eight weeks interval to ensure that it was passively fitting in the bracket slot to allow full expression of torque subscribed in bracket[6].

After full canine retraction had been achieved, 1st CBCT was taken (CB 1) for each case using CBCT machine "SOREDEX SCANORA 3D" with scanning time average 18–34 s, Effective exposure time 2.4-6s. with scanning program (60-90 kV, 4-10 mA, focal spot 0.5mm) was used. Each image was converted to DICOM format with its software.

In group A, replacement of proper size of the prefabricated 17 x 25 TMA closing T- Loop for each case was carried on with activation of 3 mm in each visit for both sides then cinching back the wire behind the molar tube. At the end of this step, all spaces were completely closed, proper contact between all teeth was fulfilled and class I canine relationship was maintained. Fig (4)

Fig. (4): Anterior segment retraction with closing loop.

In group B, a preformed torquing spring in combination with power chain were fitted to retract the four anterior incisors as shown in (Fig 5,6).

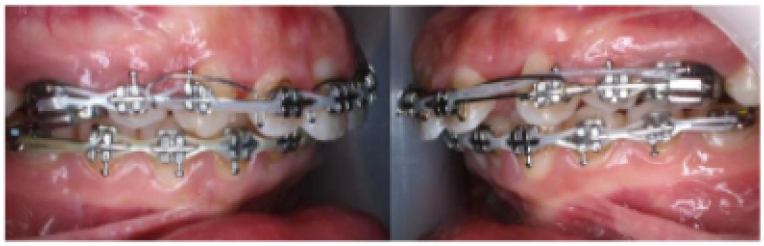

Fig. (5): Frontal view torqueing spring. Fig. (6): Right and left side view torqueing spring

For both groups when anterior segment retraction took place, a post-operative CBCT was taken (CB 2) to evaluate the amount of change in torque of posterior teeth following the process of retraction.

CBCT Measurements:

Data collection for Evaluation process:

Concerning evaluation of posterior teeth inclination, CBCTs were taken before and after retraction of the maxillary incisors to assess the amount of change in torque in buccal segment during the process of retraction.

A 3D analysis using a specific software program was used for comparison between the treatment outcomes of the two different methods of anterior tooth retraction and the changes of buccal segment torquing. Image processing softs are "Mimics Innovation" was used to fully reconstruct 3D volume tricimage by generating of sagittal, coronal, and axial multi-planar projections. Landmarks localization was determined by using the generated 3 multi-planar projections.

To minimize the identification error and increase the accuracy, the reference landmarks were chosen and identified according to several considerations as recommended by Lagraverea et al (2009)[7]. Landmarks localization had to be carried out on axial, sagittal and coronal tomographic slices, and then checked on the 3-D rendering. The choices of landmarks were customized based on the type of treatment and measurement that were assessed.

To identify the points, lines and planes on each CBCT images ome steps have to be done.

A- Three-dimensional cephalometric reference landmarks:

1. Orr - Orl (orbitale): the most inferior point of each infra- orbital rim.
2. Por- Pol (porion): the most superior point of external auditory meatus.
3. U6MBCPr – U6MBCPl (maxillary 1st molar mesio-buccal cusp tip point): the tip of the mesiobuccal cusp of 1st molar.
4. U6MBRPr – U6MBRPl (maxillary 1st molar mesio-buccal root point): the apex of the mesiobuccal root of maxillary 1st molar.
5. U5BCPr – U5BCPl (upper 2nd premolar buccal cusp tip point): the tip of 2nd premolar of each maxillary 2nd premolar.
6. U5BRPr – U5BRPl (upper 2nd premolar buccal root tip point): the apex of 2nd premolar buccal root of each maxillary 2nd premolar.

B- Three-dimensional Reference Lines and planes:

From the selected landmarks, the following reference lines and planes were constructed.

1- U6 long axis: The line connecting U6MbCP and U6MbRP.

2- U5 long axis: The line connecting U5MbCP and U5MbRP.

3- FHP (Frankfort Horizontal plane): established by Orr, Orl and Por or Pol points.

N.B: The software doesn't allow more than 3 points only to be inserted to create a 3D plane.

C- Three-dimensional measurements:

From the previously mentioned landmarks, lines, and planes, the following measurements were taken to evaluate the three-dimension altooth movement. (Table 1).

Table (1): three dimensional measurements of buccal segment

Measurements	Definition
UR 5 Torque	By measuring the angle formed between the Fronta Plane and the UR 5 longaxes.
UL 5 Torque	By measuring the angle formed between the Frontal Plane and the UL 5 long axes.
UR 6 Torque	By measuring the angle formed between the Frontal Plane and the UR 6 long axes.
UL 6 Torque	By measuring the angle formed between the Frontal Plane and the UL 6 long axes.

Measurements were taken on both the pretreatment and post-treatment CBCT.

Statistical analysis

All data collected were added to the SPSS statistic software and descriptive statistics were performed.

3. Results

The obtained results were inputted in SPSS software and independent t-tests were used to explore the linear and angular estimations for both pre- and post-treatment results for all groups, with a significance level of ($P < 0.0001$).

This means that the P value is significant and we are going to reject the null hypothesis.

Descriptive data were performed in mean and standard deviation:

1- Closing loop:

The inclination of upper four posterior teeth pre and post retraction was measured and difference was calculated (Table 2).

Table (2): Descriptive data of the inclinations of upper posterior teeth pre and post retraction using closing loop.

Paired Samples Test								
Measurement	Mean	Std. Deviation	Std. Error Mean	lower	upper	t	df	sig. (2-tailed)
pre.UL5.torque-post.UL5.torque	-1.46333	9.00409	5.19851	-23.83073	20.90407	-0.281	2	0.805
pre.UL6.torque - post.UL6.torque	-1.73333	2.07695	1.19913	-6.89277	3.4261	-1.445	2	0.285
pre.UR5.torque - post.UR5.torque	2.53	1.94772	1.12451	-2.3084	7.3684	2.25	2	0.153
pre.UR6.torque - post.UR6.torque	-2.18333	1.09861	0.63428	-4.91242	0.54575	-3.442	2	0.075

There is statistically insignificant difference between buccal segment torque during anterior retraction using closing loop.

2- Torque Spring:

The mean and standard deviation were calculated viewing the difference between the pre and post retraction results (Table 3).

Table (3): Descriptive data of the inclinations of upperposterior teeth pre and post retraction using torque spring.

Paired Samples Test								
Measurement	Mean	Std. Deviation	Std. Error Mean	lower	upper	t	df	sig. (2-tailed)
pre.UL5.torque-ost.UL5.torque	-0.75	2.84257	2.01	-26.28947	24.78947	-0.373	1	0.773
pre.UL6.torque-post.UL6.torque	-0.93	0.98995	0.7	-9.82434	7.96434	-1.329	1	0.411
pre.UR5.torque-ost.UR5.torque	0	5.71342	4.04	-51.33307	51.33307	0	1	1
pre.UR6.torque-ost.UR6.torque	-1.21E+01	10.51468	7.435	-106.53563	82.40563	-1.623	1	0.352

There is statistically insignificant difference between buccal segment torque during anterior retraction using elastomeric chain with torqueing spring.

Comparison was done between the two groups showing statistically significant difference between buccal segment torque during anterior retraction using closing loop and torque spring. (Fig 7)

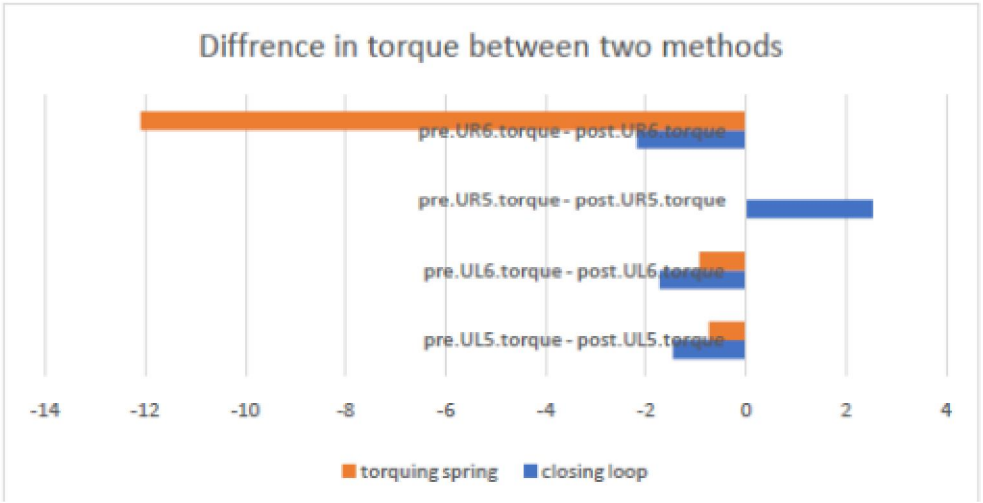

Fig (7): Descriptive data analysis of the difference of inclinations of upper four posterior teeth between the two groups

4. Discussion

The goals of Dr. Lawrence Andrews were to develop a group of orthodontic brackets where the edgewise hole is inserted into each bracket by the mechanized procedure in such a fashion that predetermined torque and angulation angles are produced amid the occlusal plane and the long axis of each tooth when a full sized archwire is applied [8]. With this mechanized procedure, the proper in-out, up-down and torque association among the teeth would also be recognized. This counteracts the necessity to put in first, second, and third order alignment bends into every archwire.

Accordingly, establishing proper alignment and angulation of the anchorage units is a proof of realizing a successful treatment since the tooth becomes able to evenly distribute the loading stresses without being affected. Moreover, the periodontal and bony supports are preserved. To accomplish a good treatment results, it is fundamental to recognize the values following gap closure. Regulation of gap closing is finally estimated by the applied biomechanical forces, anchor unit, force-to-deflection rate, moment-to-force ratio (M/F), as well as friction state [9].

By applying Newton's third law the tipping and torque of anterior and posterior segments is significant to effectively close extraction gaps. Wook Heo et al. [9] concluded that there were no significant variations found in the degree of anchorage failure of the upper posterior teeth and the quantity of retraction of the upper anterior teeth linked with en masse retraction and two-step retraction of the anterior teeth [10].

Before starting anterior teeth retraction, and after full canines retraction, a CBCT (Pre-retraction) was taken to provides vital diagnostic information regarding dental and skeletal parameters. [11-14] In the presence of the CBCT more accurate cephalometric parameter was achieved to evaluate the different state of the posterior teeth before and after retraction using the two different methods.

Concerning retraction techniques, both techniques were depended upon in each of the two groups. In the first group, torqueing spring was used in combination with power chain. This latter represents the frictional (sliding procedures) in which a plain archwire slides within the brackets and tubes on the posterior teeth. Applying power through coil springs or power chain elastics in sliding procedures produced friction within the archwire and the bracket slot, the tooth feels minimal power than the orthodontist is in reality applying. [15] The directive wire gives moments needed for avoidance of tipping and rotation. [16]. on the other hand, the effectiveness of this modality of gap closing may be compromised owing to friction. [17]. Some authors [18], reported that when the wire size increased, the tipping of the canine and the movement of the anchor teeth decreased. The perfect archwire dimension would diminish adverse side effects from sliding procedure to get the greatest translation of teeth in to extraction places. So, 0.017 x0.0 25-inch archwire was used in order to maintain the same friction state.

It is common to use 17 x 25-inch rectangular stainless-steel arch wire with 18 slot appliances during the finishing stage, and active torque with these arch wires. In case of 22 slot appliances, full dimension rectangular stainless-steel wire (19 x 25 inch or 21 x 25 inch) are far too stiff to be used for clinically effective torque, therefore they may never be used. [19] In this study, the 22 slot size was depended upon. This allowed to retract canines and the four anterior teeth

with minimal friction with the 17 x 25 -inch rectangular arch wire.

In our study, the ART (Anterior Root Torque) Auxiliary was used. It implements a unique approach to rootт or quing [20]. In addition to ROTH torqueing criteria incorporated in the bracket, The ART auxiliary torquing incorporates extensions to apply pressure on the teeth very near the gingival margins to affect palatal root movement. [21] Beside torqueing considerations, the ART has many advantages. It is a highly resilient 0.016" inch wire containing 15% nickel. It is available in different sizes for more applicability. The hooks are annealed for easy opening and closing around the main arch wire few times for arch-wire changes. It is more hygienic for patient. Finally, the most important is the reduction of the amount of wire bending.

Concerning torquing spring size selection, the end of the spring must be ended at distal point of canine brackets to provide enough range of sliding through the wire and to prevent the lock that may happened when the distal end of the spring touch the mesial aspect of second premolar bracket and space closure may stopped.

To achieve the stability of powers and couples created at the site of power appliance through a definite quantity of activation, the physical characteristics of the withdrawal coil or loop should be calculated. Estimation of this equilibrium is correlated to the location of the core of resistance (CR) of the segments [22]. In frictionless procedure, there is no wire for guide. Therefore, there is no loss of practical power as result of sliding friction. The random loss of power is on no account an issue in loop procedure for the reason that it is frictionless. It's the method which has the prospective to create best M/F ratios for precisely performed controlled mobility of the anterior teeth as expected [10,23,24]. On the other hand, the M/F ratio generated by the conservative vertical or teardrop loop is as well low down to perform controlled mobility of the anterior teeth [24-29]. The most significant mechanical characteristic of the loop is the M/F ratio for the reason that it verify the center of rotation and accordingly the mobility prototype of the tooth throughout closure to teeth space [10,28,30].

Many trials were carried out by the clinicians and investigators, for gaining as possible of high moment-to-force ratios, through suggesting and manipulating loop geometry. The foremost mechanical loop characteristics are the vertical force, load/deflection and moment-to force ratio. Between these measures, the moment-to-force ratio can be taken as the more important measure because it has been correlated to the kind of tooth movement [28]. Regarding space closure using closing. The main goal of applying closing loops in orthodontics either with segmental or continuous archwires is to create the preferred powers and moments to shift teeth in a expected way. Therefore, no friction is created among wire and bracket, the force librated by loops can be used directly to a tooth or a group of teeth [28]. Beside being friction free, T-loop (0.017 x 0.025-inch) provides a constant M/F [17]. T-loop has other many advantages among which is the construction of equal and reverse alpha and beta moments at complete commencement. Smooth gradual curvature for the pre-activation bends is also assured. Precise control of tooth movement during retraction is also attained [31]. Moment-to force ratios of around 10/1 is an indicator for translation, whereas, the ratio 7/1 is an indicator for controlled tipping [32]. At these comparatively high levels of moment-to-force ratio, stresses apparently allocate more consistently during the entire root with negligible differences in the mechanical characteristics throughout activation. This diminishes harms to teeth and neighboring tissues. Kuhlberg and Burstone [32], demonstrated that the M:F ratio in 0.017 x 0.025-inch titanium-molybdenum alloy (TMA) T-loops can approximate 12:1 at 2.5 mm of activation of a centered symmetric T-loop spring. The linear activation of T-loops above 3 mm on the other hand resulted in M:F ratio decreased (10:1). This would not result in pure bodily retraction of a tooth.

In general, the moment-to-force ratio will be high, and an extrusion force is found at the shorter end when a closing loop is placed near an anterior segment, whereas at the contrary, long end the moment-to force ratio is minimal, and the vertical power is invasive [10]. The T-loops, in this study, were positioned in midway between the two segments to avoid any intrusion or extrusion effect on both segments during space closure.

In this study the Frankfort horizontal plane was selected. For more accuracy, it was based on three points (Right and left orbitals and right porion) instead of base of the skull (S-N plane) where only two points are depended upon. In this method, the points were selected on the basis of conventional cephalometric landmarks. This method proved to be reliable, convenient and easily applicable. It was claimed that the point orbital (OR) is the most reliable landmark in the anterior mid face region, and porion (PO) is the most reliable land mark in the posterior segment. all pre-activated TMA and NiTi closing-loop specimens produced an M:F ratio 10:1 at some point in their deactivation range, irrespective of the force delivered, which contradicts with our study in which we couldn't produce full M:F ratio 10:1 either within torqueing spring nor closing loops [34]. According to **Mayumi Sumi et al** [35] the best possible force level and M/F ratio for getting controlled movement of the anterior

teeth can be created by just diminishing 1/2 the thickness of a teardrop loop (height 10 mm and cross-section 0.019 x0.025 or 0.021 x 0.025 in) for a distance of 3 mm from the loop apex, and fixing it through a 1/4 and a 1/3 of the inter-bracket distance from the canine bracket, While the prefabricated closing T-loop can't produce controlled bodily movement of anterior teeth.

On the other hand, the segmented advance is a clinically beneficial as it permits concurrent control of tooth movement in the axial, sagittal and vertical levels. Furthermore, the propose of this application enables the orthodontist to carry a well-controlled, statically estimated force method in which only least chair side adjustments are needed, which is not in accordance with our results [(36)].

According to this, torque value on buccal segment in torqueing spring group was affected as the retraction of anterior segment was done by sliding mechanics and M:F ratio was high in the anchor teeth. Conversely, in closing loop group, frictionless mechanics was done and M:F ratio was lower in anchor teeth. So, the effect of moment in friction mechanics is higher than in frictionless mechanics in buccal segment area.

Conclusion

Using of torqueing spring appliance affect the torque value on the buccal segment than the TMA closing preformed (T-loop).

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