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The Relation between Type of Ligature and Force Delivered by Orthodontic Arch Wire

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الخلاصة

الأهداف: تهدف الدراسة إلى مقارنة قوة التسريح المتولدة نتيجة تحرير السلك التقويمي من (٤ إلى٥ .٢) مليمتر بالاتجاه الأفقي في منطقة الناب العلوي الأيمن، على قالب قياسي للأسنان باستخدام ثلاث طرائق مختلفة لربط السلك بالحاصرات. **ألمواد وطرائق العمل:** ثلاث مجموعات من الحاصرات بقياس شق (0.028× 0.022) انج ، ثلاثون سلك، نوع نيكل تيتانيوم المشكل مسبقا بشكل قوسي و بقياس (0.016) انج ، قسمت إلى ثلاث مجاميع وفقا لطريقة الربط: المجموعة الأولى ربطت بروابط سلكية ، المجموعة الثانية ربطت بروابط مرنة بالشكل (**o**) وفي المجموعة الثالثة بروابط مرنة بالشكل (**c**). تمت القياسات بدرجة حرارة الغرفة ٥± ٢٧ ,في وسط جاف و بواسطة جهاز مصمم في كلية الهندسة الميكانيكية/ جامعة الموصل وقورنت النتائج بين الأنواع الثلاثة من الروابط. **النتائج:** لوحظ فرق معنوي ($p \leq 0.05$) بمعدل القوة المتولدة ، حيث أن استخدام الرباط المرن بالشكل (**c**)يجعل السلك التقويمي يولد معدل للقوة (٣٣٢ غم) ، أعلى من معدل قوته في حالة ربطه بالرباط المرن بالشكل (**o**) أو بالرباط السلكي (٢٦٨ غم) ،(٢٦٧غم) على التوالي.**الاستنتاجات:** أن تقليل قوة الربط باستخدام الرباط المرن بالشكل (**c**) لربط السلك بحاصرات أل(synergy) كافي تماما في بداية مرحلة التسوية والرصف، ذلك لأنه يسمح للسلك التقويمي بتوليد قوته بدون ضياع كبير نتيجة الاحتكاك العالي الذي ينتج باستخدام الرباط المرن، بالشكل (o) أو الرباط السلكي.

ABSTRACT

AIMS: This in vitro study aims to compare the deactivation force, delivered as a result of releasing superelastic arch wire from 4 mm to 2.5 mm in horizontal direction at the area of right maxillary canine on standard model of teeth, by using three different methods to ligate the wire to the brackets. **MATERIALES AND METHODS**: Materials of this study include three sets of Synergy brackets 0.022 x 0.028 inch, molar buccal tubes, thirty arch wire , 0.016 inch round preformed arch superelastic nickel-titanium wires, were divided to three groups according to ligation method, the first group was ligated with preformed steel wire ligatures ,the second group with elastic ligatures as **o** configuration and in third group with elastic ligature as **c** configuration. The measurements were completed at room temperature of 27±5 in dry media by machine designed by college of mechanics engineering /Mosul university and the results were compared among the three methods of ligation. **RESULTS:** Significant difference in deactivation forces ($p \leq 0.05$) were observed. **C** configuration elastic ligatures had the higher mean of deactivation force (332 gm) than either **o** configuration or steel wire ligatures (268.5 gm), (267.9 gm) respectively. **CONCLUSIONS:** Decreasing the ligation force by using **C** configuration elastic ligatures to ligate the wire to Synergy bracket is potentially adequate to use at the beginning of leveling and aligning stage of orthodontics that allow the arch wire to generate its force without more missing due to high friction, as occurred by the use of stainless steel wire ligatures or **o** configuration elastic ligatures.

Keywords : Synergy brackets, orthodontic ligatures, deactivation force.

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INTRODUCTION

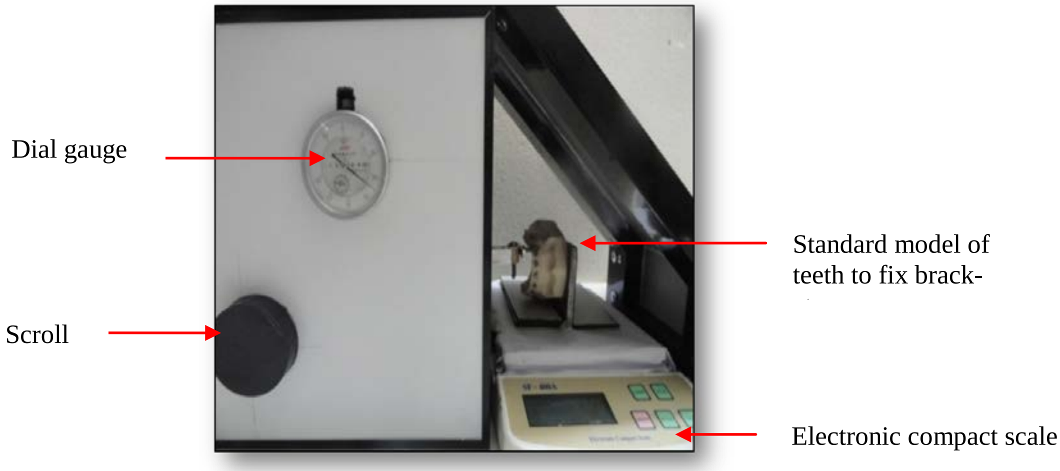
The fixed orthodontic appliance, which is responsible for the delivery of force, is selected and activated by the clinicians [1] and the force that plays a role to align and level the teeth is not the activation force, but the deactivation force of the appliance [2] that is of more clinical interest, because it is more closely approximate to the forces that causes tooth movement during orthodontic treatment. [3] The main part of fixed appliance is the arch wire that inserted to bracket slot and ligated with different method of ligation, wire ligatures and elastomeric ligatures have been the two most common forms of conventional bracket-slot closure throughout the history of orthodontics. With these conventional ligation, the frictional force is a constant during all orthodontic treatment, and it plays a critical role on the level of force transmitted to dentition.[4] The Synergy bracket (low friction bracket) features six wings instead of the classic four wings of conventional twin bracket was used in this study. The curved walls in the synergy arch slot (like the humps of a camel) reduce contact between wire and the metal of the arch slot, further reducing friction.[5] Indeed, orthodontic appliances currently employed in orthodontic mechanics must transmit to the brackets adequate level of force to overcome the frictional forces that oppose sliding between wire and bracket and to exert on the periodontal ligament (PDL) an appropriate amount of residual force to produce dental movement. [6] The aims of this study were to compare the deactivation force, delivered as a result of releasing superelastic arch wire from 4 mm to 2.5 mm in horizontal direction at the area of right maxillary canine on standard model of teeth, by using three different methods to ligate the wire to the brackets.

MATERIALES AND METHODS

Roth edgewise conventional stainless steel brackets of six wings known as Synergy bracket 0.022 x 0.028 inch (Rocky Mountain Orthodontics, USA). Bondable Buccal Tubes Low Profile Design. Metal injection Molded (MiM Technology) 0.22 (lancer orthodontics, California). Arch wires used in this study are 0.016 inch round preformed arch-super elastic nickel-titanium wires manufactured by International Orthodontics Services (IOS) (made in USA) and came from the same batch to avoid possible inter batch discrepancies Preformed steel wires ligature, short 0.25mm/10 (Dentaurum, Germany). Elasticlitures,silvermetallic4,038.7534,217,686 (Dentaurum, Germany).

Universal Testing Device:

Testing device as shown in (Figure 1) consists of electronic compact scale SF-400A with external sensor bearing, at its end, horizontal and vertical rods on the end of the rod the bracket of the removed canine was fixed . Two metallic base support for either horizontal or vertical measurements stabilized on the compact scale to fix the model of teeth after bracket fixation. Dial gauge for measuring the wire deflection. Movable arm moved up and down by a scroll to control deflection manually at rate of 0.01mm/sec. Dial gauge and external sensor are connected to the movable arm. Electronic compact scale and movable arm fixed on the heavy metal base.



Figure(1): Universal testing machine

Testing and Measurements

This study includes 30 tests, the test for each type of ligatures was repeated 10 times. Every test the materials (wires and ligatures) were replaced with new ones while buccal tubes and brackets were replaced with new set after each ten tests. Buccal tubes and brackets fixed on standardized model of maxillary teeth that used in orthodontic study after was prepared by removing the right maxillary canine to allow deflection of arch wires here.

Molar tubes were firstly bonded in the middle third of the buccal surface of the right and left first molars by bonding material (adhesive A & B) mixing equal amount of A resin with B hardener as in manufacturer's instructions. Brackets, from second-premolar to that of the contra lateral second-premolar, excepting at the maxillary right canine, were bonded using bracket gauge to fit each bracket in its accurate position on each tooth surface (in middle third of each tooth surface) . After that, the model of teeth fixed on the horizontal base support and fix the bracket of right canine to horizontal deflecting rod that every test was positioned at the midpoint of 15mm (measuring the distance between the center of the lateral and the center of the first premolar by digital vernia and determined the midpoint at area of right canine on the model).After that, the wire was inserted in the buccal tubes and tied to all brackets by the ligatures then cutting the wire with distal end cutter at a point marked on the model at the buccal fissure of upper second molar at each sides (to achieve same length of all arch wires that used). The dial gauge and compact scale referred to zero deflection loads when the deflecting rods are aligned in the area of missing canine at the midpoint between lateral and first premolar (when the bracket of missing canine leveled with other brackets of the model of the teeth) and this consider the constant position of model on base support before each test). when moving the arm by the scroll at rate of 0.01mm/sec the engaged wire was deflected (activated) palatelly then released the wire by same rate and measured deactivation force (unloading) at 2.5 mm.

Statistical Analysis: SPSS version 11.0 for windows statistically analyzed the data collected ,and that includes; Descriptive statistics of minimum, maximum, mean, standard deviation and standard error. One-way analyses of variance initially analyzed the data then analyzed by Duncan's Multiple Range Test to locate the significant differences among the groups.

RESULTS

Descriptive statistics in Table (1) showed that the minimum values by using **c** configuration, **o** configuration , and steel wire ligatures were (330gm), (265gm) , and (267gm) respectively; the maximum values were (335 gm),(270gm), and (268gm) respectively; mean values were (332 gm), (268.5 gm), and (267.9 gm) respectively. One-way analyses of variance in Table (2) showed that there was significant difference ($p \leq 0.05$) . Duncan's Multiple Range Test in Table (3) showed that the c configuration gave higher mean (332 gm) than o configuration and steel wire ligatures and there was no difference in the effect of two latter ligatures .

Table(1): Descriptive statistics of deactivation force for the three ligatures at 2.5 mm using Synergy bracket and 0.016 inch nickel titanium wire.

Ligature	No.	Minimum	Maximum	Mean	SD	SE Mean
C elastic	10	330	335	332.00	2.055	.650
O-elastic	10	265	270	268.50	2.415	.764
Steel wire	10	267	268	267.90	.316	.100

Table(2): One–way analysis of variance of deactivation force among the three ligatures at 2.5 mm using Synergy bracket and 0.016 inch nickel titanium wire.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	27138.067	2	13569.033	4008.358	.000
Within Groups	91.400	27	3.385		
Total	27229.467	29			

SOV: Source of variance; SS: Sum of squares; MS: Mean square; df: Degree of freedom.

Table(3): Duncan's Multiple Range Test for comparison the differences in the deactivation force among the three ligatures at 2.5 mm using Synergy bracket and 0.016 inch nickel titanium wire.

Ligature	No.	Mean	Duncan's Grouping*	
C elastic	10	332.00	A	
O elastic	10	268.50		B
Steel wire	10	267.90		B

* Means with different letters were statistically significant ($p \leq 0.05$).

DISCUSSION

In this study, the method of ligation by **c** configuration elastic ligatures were demonstrated the higher mean of the deactivation force than conventional ligation method by either **o** configuration elastic ligatures or steel wire ligatures , this related to ligation forces (frictional forces) produced by both conventional ligatures that apply a force pushes the arch wire against the bottom of the bracket-slot. So the frictional force by them is a constant during all orthodontic treatment[4]. If the friction level is high, part of the force generated by the orthodontic wire is needed to overcome the frictional force and is thereby lost. So that , only the remaining part of the force can be transferred to the teeth and cause their movement. Lower levels of friction will therefore reduce the force lost. [7] Ligation forces can be reduced or eliminated by making use of suitable bracket designs and ligation that keep the wire in the lumen slot and avoid pushing the arch-wire against the bottom of the slot, thus leading to reduced friction that play a critical role on the level of the deactivation force [4], the deactivation force as mentioned previously is of more clinical interest, because it more closely approximates the forces that cause tooth movement during orthodontic treatment [3] , consequently as the method by which the arch wire is ligated to the bracket can significantly affect friction[8-12] it affect the deactivation force .With **c** ligation method the friction was reduced by increasing amount of wire between brackets and not full engagement of arch wire to slot of brackets was occurred (keep wire in lumen slot and avoid pushing the arch wire against bottom of slot) as shown in (Figure 2). This increases the flexibility of wire and reduces or eliminates the ligation forces (frictional forces). [4]

Figure(2): “c” configuration elastic ligatures used with Synergy brackets

In contrast, the full engagement of arch wire to slot of synergy brackets by using both conventional ligatures (‘O’ ligation and steel wire ligatures) produce lower force mean than C ligation this related to that synergy bracket become high friction system with conventional ligation that pushed the arch wires against the bottom of bracket's slot leading to decrease flexibility of wire and increase ligation force (frictional forces) as a result decreasing the deactivation force due to more loss in the force of wire as a result of high friction . The result of no significant difference between the 'O' ligation and steel wire ligatures was agreed with the study result by Khambay *et al*. [13]

CONCLUSIONS

The method of ligation affect the deactivation force, so decreasing the ligation force will decrease the force missing of super elastic NiTi wires a result high mean of force delivered by this wire. More dissipation in arch wire's force (low deactivation force) with conventional ligatures with synergy bracket (full bracket-slot engagement) in contrast to **C** configuration ligation with the same brackets that allow the wire to exert amount of force without more lost .

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