Original Article

An Estimation of The Moments Generated in Maxillary Anterior Brackets from Inversion of Lateral Incisor Bracket in Conjunction with Different Torque Values for Canine Bracket in a MBT Set Up An Experimental Study.

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J Contemp Orthod 2020;4(2): 33-41

Received on: 07-04-2020

Accepted on: 23-05-2020

Source of Support: Nil

Conflict of Interest: None

ABSTRACT

INTRODUCTION

The third generation of the pre-adjusted bracket system was introduced by McLaughlin, Bennett and Trevesi. According to the authors, "Torque control is the weakness of the PAE system and any system based on the edgewise bracket". They have recommended adding up to 20 degrees of torque to the archwire in the upper anterior area when the 0.019" x 0.025" archwire that is commonly employed for en masse retraction fails to maintain torque in the upper incisors. Special attention is directed to the canine teeth inclinations because they are the key elements for mutually protected occlusion[1]. Depending on the patient's needs, brackets with 0, +7 or -7 degrees can be used in different clinical situations.

One important aspect of the third-order relationship of a rectangular archwire in the rectangular bracket slots, which is often overlooked, is the reciprocal effects on adjacent teeth from the twists in the archwire (The twists could be either those which are incorporated in the archwire when using standard edgewise brackets, or because of the archwire getting indirectly twisted by the built-in torque in the PAE brackets).

MBT protocol recommends inverting the bracket on an upper lateral incisor tooth[1] which is instanding, to apply labial root torque to correct its root inclination. Built-in lingual root torque in the upper central incisor bracket (+17˚) and labial root torque in the adjacent lateral incisor (-10°) would enhance the respective torquing actions on both the teeth because of the reciprocal effects of torque. Additionally, if the adjoining canine tooth is bonded with +7˚ bracket, the reciprocal effects between the canine and the lateral incisor would further enhance the torquing moment on the lateral incisor[2]. There is a danger that the moment would far exceed the optimal values for rectangular wire torque, ranging from 20 N-mm to 10 N-mm for root movement and bodily translation respectively, recommended by various authors such as Burstone[3], Nikolai[4], Meling[5] et al, and Amy Archambault[6] et al. If this happens, it could have damaging effects on the tooth as well as the periodontium. This was the finding of a recently published F.E.M study[2].

Any F.E.M. study needs to be validated by an experimental laboratory study. The present study was, therefore, conceived to evaluate the torquing moments generated in the different sizes of rectangular SS arch wires, TMA arch wires and Ni-Ti arch wires, when engaged in the above mentioned M.B.T. bracket set-up. This would help in selecting the appropriate rectangular archwire for the clinical situation involving inversion of lateral incisor bracket coupled with different torque values for adjacent canine brackets.

The aims and objectives of the present study were as follows:

1. To estimate the torquing moments generated in upper anterior brackets from inversion of maxillary lateral incisor bracket in an experimental M.B.T. setup having +7°, 0°, or

-7° torque values on the adjacent maxillary canine brackets, when arch wires of different dimensions and materials are employed viz. SS, TMA, Ni-Ti.

2. To estimate the moments generated in the above setup from 0.017"×0.025", 0.018"×0.025", 0.019"×0.025" and 0.021"×0.025" Stainless steel as well as 0.017"×0.025" and 0.019"×0.025" TMA wires with 10°, 15° and 20° additional torque built in the anterior curvature.
3. To derive clinical recommendations based on the above findings.

MATERIAL AND METHOD

Upper MBT brackets and first molar tubes in 0.022" slot size (Gemini series marketed by 3M Unitek) were used in the experiment. Rectangular archwires in three different materials viz. Stainless steel, Beta Titanium (TMA) and Ni-Ti in various sizes viz. 0.017"×0.025", 0.018"×0.025", 0.019"×0.025" and 0.021"×0.025" (as applicable) were used.

METHODOLOGY

The study was performed using an assembly that was constructed as follows:

A) Typhodont set up

1. Wax carvings of maxillary teeth with normal anatomy (Fig. No. 1) and in correct sizes were made according to Wheeler's measurements[7]. For the maxillary canine, three teeth were carved. A metal ring was placed around the teeth and light body poly vinyl siloxane rubber base impression material[8] (Fig. No. 2) (DENTSPLY GAC INC limited) was poured. When the material set, de-waxing was carried out in a hot water bath. Self-cure acrylic of thin consistency was injected into the impressions of teeth to obtain acrylic teeth with anatomically correct forms and sizes.

2. The posterior teeth were set into upper denture-like occlusal rim according to teeth setting principles[9] and the rim was then acrylized. MBT 0.022 slot brackets and molar tubes were bonded on the buccal surfaces of the premolars and first molar teeth with the help of Dougherty MBT gauges[10](Fig. No. 3), according to the MBT guidelines, using cyanoacrylate adhesive.

3. Six anterior teeth were also accurately bonded with the respective brackets. The lateral incisor bracket was inverted[1]. The three canine teeth carried brackets with +7°, 0° and -7° torque[1]. They were used in different experiments as described later. Tiny wire rings (eye lets) were fitted at the apices of the roots of both central incisors, the right lateral incisor and the right canine teeth for force application.

4. The anterior teeth were suspended on a rectangular arch wire (the size of which differed according to the experiment), which ran through the attachments on the posterior teeth (Fig. No. 4). The anterior teeth had the freedom to move freely in labial and lingual directions, when permitted (see below).

5. A white colored horseshoe shaped acrylic rim was made in such a way that it could fit over the posterior part of the denture. Two molar tubes were fitted on the top edge of the horseshoe shaped acrylic rim in the area of second premolars. A 0.021" x 0.025" stainless steel arch wire was fabricated with two horizontally projecting hooks that abutted the molar tubes, with the wire approximately following the same position as the arch wire fixed in the brackets. The wire was kept tied to the tubes using elastomeric modules so that the wire would not move in the antero-posterior direction (Fig No. 5). This wire served two purposes:

    a. It acted as a reference for locating the teeth apices of the anterior teeth and measuring the change in their location after the force was applied.

    b. It carried four rectangular tubes, which could slide along the anterior curvature. Short pieces of 0.021" x 0.025" wires were soldered to these tubes before the arch wire was threaded through them. Bends were made in these short wire pieces in such a way that their ends would grip the root apices to prevent their movement when desired.

    The horseshoe shaped rim was fixed to the posterior part of the denture using two nut-bolts on either side, so that the two could be separated when necessary (Fig. No.6).

6. This acrylic rim had the provision to attach to an acrylic flat plate (Fig No. 7) with the help of a nut-bolt arrangement. The acrylic plate was permanently fitted to the end of a copper rod pedestal (Fig. No. 8). The copper pedestal rod was inserted into a hollow iron tube (that was slightly larger in dimension), which was welded to a metal strip. The latter was fitted on a wooden plank with the

help of a screw. This arrangement permitted some movement of the iron rod when needed.

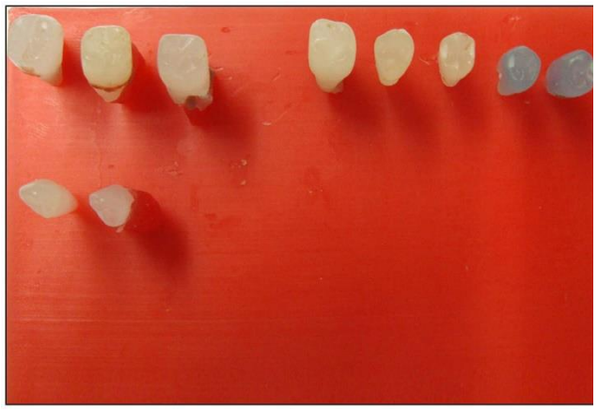

Fig 1. Wax carvings of various teeth

Fig 2. Anterior and posterior teeth impressions

Fig 3: Dougherty MBT gauges

Fig 4. Anterior teeth suspended on the rectangular arch wire

The copper rod along with the typhodont assembly could not only be rotated through 360 degrees but its height also could be adjusted as required; and then the position could be stabilized with the help of bolts which could be operated through the nuts welded to the side of the iron rod.

Fig 5 Horse shoe shaped acrylic rim with reference wire attached
The reference wire carries stabilizing wire pieces on sliding rectangular tubes

Fig 6. Horse shoe shaped rim fixed to the posterior part of the denture

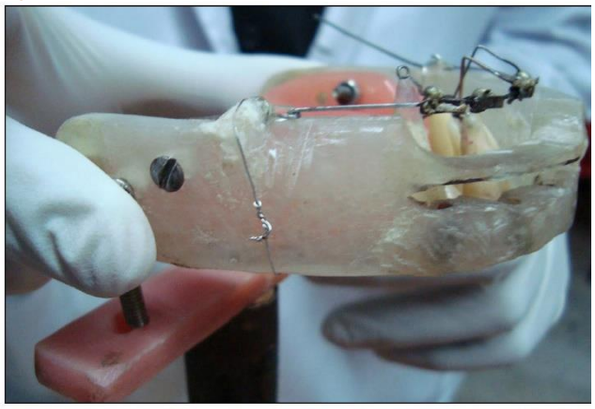

Fig 7. Acrylic rim being fitted to the flat acrlic plate fixed to the top of the copper pedestal

Fig 8 Copper pedestal rod assembly

B) Force measurement assembly

Force measuring gauge Fig. No. 9) : The force gauge (Lutron, model number FG-5000A and with ISO 9001:2000 certification, Ukas quality management certificate and CE certification) made in Taiwan with H.86551 number was used in this experiment. Measuring capacity was maximum of 5000 Grams or 49.03 Newtons and a minimum of 1 Gram or 0.01 Newtons. The circuit has the Microprocessor LSI.

C) Alignment of the force-measuring gauge with the typhodont assembly (Fig. No. 10):

A bench press was secured in the middle of the same wooden plank in such a way that the side rods of the press and the adjustable central screw were in the same plane as the iron rod carrying the typhodont. However, the screw was inverted and a metal plate was welded to its end. A metal trough was prepared which could hold the gauge securely. It was kept resting on the metal plate. To ensure that the plate carrying the gauge moved only vertically (and did not rotate), two metal sleeves were additionally welded on either sides of the bench press. Thus turning the piston would raise or lower the gauge vertically to the required positions. A mason's spirit level was used to make sure that the gauge was perfectly horizontal. The trough was welded to a bolt, which, guided by two nuts, could carry the trough along with the force measuring gauge forward or backward (Fig. No.11).

Fig 9. Lutron Force Gauge

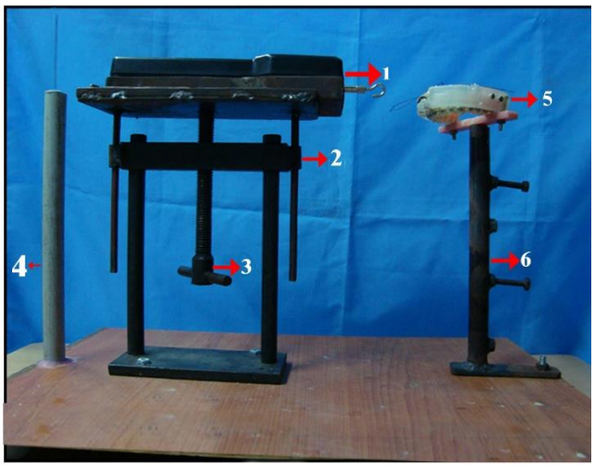

Fig 10: Alignment of the force measuring gauge with the typodont assemb

1.Force gauge
2.Anti rotational sleeve
3.Force gauge vertical adjustment screw
4.Parallelling rod
5.Horse shoe shaped rim with the denture
6.Copper pedestal rod in a hollow iron tube

Fig 11. Bolt guided by the nuts to move the force gauge forward (or) backwa

Fig 12: Force gauge set at zero reading

Fig 13: Force gauge showing reading for root displacement measured with the divider

EXPERIMENTAL PROCEDURE

1. The two centrals were presumed to be slightly lingually inclined, thus needing further lingual root torque. With reference to the guide (0.021" x 0.025") wire the distance of the apex was estimated to be 9 mm.

2. The lateral incisor root was presumed to be palatally placed, thus needing labial root torque. With reference to the guide (0.021" x 0.025") wire the distance of the apex was estimated to be 15 mm.

3. The right canine root was kept upright or slightly palatally tipped for different experiments. With reference to the guide (0.021" x 0.025") wire the distance of the apex was estimated to be 8 mm for the upright position.

4. For measuring the force on any tooth, at least one tooth on either side was stabilized using the procedure mentioned above. The tooth, on which the force was to be measured, was released and permitted to take the position, which was dictated by the wire bracket relationship. Then a surgical silk thread was tied from a small wire ring fixed to the apex (eyelet) at one end and the hook of the measuring gauge at the other end. The tooth root was slightly moved manually till it started feeling some resistance, so as to eliminate the bracket slot/arch wire play. At this point, the measuring gauge was shifted horizontally till the thread became slightly taut. Then the zero position of the gauge was switched on (Fig No. 12). The root apex was moved in the required direction in three steps of 3mm, 5mm and 7mm by rotating the screw that pulled the tension gauge horizontally. The actual root displacement was measured using a divider, taking the 0.021" x 0.025" wire as the reference. The gauge readings were recorded (Fig No. 13) at 3mm, 5mm and 7mm displacement respectively,

wherever possible. (In some situations, the root apex as dictated by the archwire, was close to the pre-determined position. Hence, it could be moved only by 3 mm, or up to 5 mm but not by 7 mm. In such instances, only the first step, or first and second step readings could be taken and not all the three step readings.) The readings were repeated 3 times and their average was taken.

5. Then that tooth was stabilized, the next tooth was released and the procedure was repeated for measuring the force needed for displacement for 3 mm, 5 mm, and 7 mm. The typhodont was rotated, or raised/ lowered so that the line of force was properly directed.

6. The experiment was repeated for different archwires (differing materials, sizes and torques).

RESULTS

1. With an increase in the arch wire dimension, the corresponding force values showed a progressive increase, as would be expected. The force developed at the apex for 3 mm displacement of the central incisor progressively increased from 0.23 Newton in a 0.017" x 0.025" SS wire to 0.42 Newton in a 0.018" x 0.025" SS wire to 1.26 Newtons in a 0.019" x 0.025" SS wire to 2.01 Newtons in a 0.021" x 0.025" SS wire. The progression was almost doubling for every increase of 0.001-height in wire dimension.

2. The force generation was more for the SS wires than for the TMA wires and the least for the Ni-Ti wires in corresponding arch wire sizes. When the play of the under sized arch wire in the slot was more (as for example a 0.017" x 0.025" arch wire in the 0.022" slot), the difference between the values of the force produced was relatively less. As the play decreased (either because the arch wire size increased or because of alternating lingual and labial torques on the succeeding teeth), the differences became more manifest.

3. The torque combinations of positive torque on the central incisor, negative torque on the lateral incisor and positive torque on the canine produced higher forces at the apices of the lateral incisors, than the combination of positive torque

Table : 1

ARCH WIRE	CENTRAL				LATERAL			CANINE		
	Displacement	SS	TMA	NiTi	SS	TMA	NiTi	SS	TMA	NiTi
0.017" X 0.025" AT 0, CT 0	3 mm	0.23	0.14	0.12	0.42	0.23	0.32	0.15	0.1	0.06
	5 mm	0.47	0.31	0.22						
0.017" X 0.025" AT 0, CT +7	3 mm	0.34	0.25	0.1	0.63	0.3	0.27	0.19	0.11	0.07
	5 mm	0.62	0.5	0.22				0.3	0.22	0.15
0.017" X 0.025" AT 0, CT -7	3 mm	0.32	0.24	0.18	0.13	16	13	0.14	0.1	0.06
	5 mm	0.84	0.52	0.29				0.42	0.21	0.12
	7 mm							0.87	0.38	0.28
0.017" X 0.025" AT 10, CT 0	3 mm	0.27	0.2		0.47	0.31		0.2	0.1	
	5 mm	0.53	0.41					0.47	0.29	
0.017" X 0.025" AT 10, CT +7	3 mm	0.26	0.16		0.54	0.19		0.13	0.1	
	5 mm	0.55	0.31					0.28	0.21	
0.017" X 0.025" AT 10, CT -7	3 mm	0.26	0.19		0.09	0.16		0.09	0.1	
	5 mm	0.67	0.39					0.34	0.27	
	7 mm							0.65	0.57	
0.017" X 0.025" AT 15, CT 0	3 mm	0.33	0.3		0.57	0.39		0.25	0.13	
	5 mm	0.64	0.4					0.56	0.29	
	7 mm		0.56							
0.017" X 0.025" AT 15, CT +7	3 mm	0.28	0.21		0.53	0.21		0.19	0.13	
	5 mm	0.58	0.41					0.32		
0.017" X 0.025" AT 15, CT -7	3 mm	0.44	0.23		0.24	0.2		0.17	0.12	
	5 mm	0.74	0.4					0.62	0.28	
	7 mm							1	0.41	
0.017" X 0.025" AT 20, CT 0	3 mm	0.52	0.4		0.9	0.57		0.42	0.19	
	5 mm	0.95	0.5					0.79	0.4	
	7 mm	1.21	0.66							
0.017" X 0.025" AT 20, CT +7	3 mm	0.44	0.23		0.53	0.26		0.32	0.17	
	5 mm	0.88	0.52					0.5		
0.017" X 0.025" AT20, CT -7	3 mm	0.36	0.28		0.33	0.18		0.19	0.16	
	5 mm	0.57	0.43					0.49	0.31	
	7 mm							0.72	0.42	

All measurements are in Newtons

The figures highlighted in Red colour indicate generation of excess moment

*AT = Anterior torque in the wire

** CT = Torque in the Canine Bracket

Assessing the moments experienced by the teeth under different situations:

Since, measuring the moment on any tooth was not possible in our set up, the force at the apex was measured using the gauge. The force was then multiplied by the distance of the apex from the bracket to calculate the moment (moment = Force x ⊥Distance). The distance of the root apex to the bracket for the central incisor, lateral incisor and the canine tooth in our set up was 20 mm, 19 mm and 22.5 mm respectively.

on the central incisor, negative torque on the lateral incisor and zero-degree torque on the canine. The least amount of force generation was observed with the combination of positive torque on the central, negative torque on the lateral incisor and negative torque on the canine.

DISCUSSION

One of the objectives of the study was to estimate the moments generated with inversion of lateral incisor bracket, and whether they could be so large as to pose danger to the dental and periodontal tissues. We will first outline our rationale in deciding which levels of forces at the teeth apices (when converted into moments) were considered as abnormally high.

20 mm, 19 mm and 22.5 mm respectively. Dividing the 20 N-mm limit by these distances the permissible maximum forces on these teeth would be 1 Newton, 1.05 Newtons and 0.88 Newtons respectively. Adding 25% to these force levels the maximum permissible force level for our experiment were fixed at 1.25 Newtons, 1.31 Newtons and 1.1 Newtons for the central incisor, the lateral incisor and the canine respectively. Forces exceeding these levels have been highlighted in red color in the table numbers 2,3,4.

Forces generated on the central and lateral incisors in certain cases were very high as can be made out from table numbers (2,3,4). This was particularly true with 0.019" x 0.025" SS wires, which are the most commonly used arch wires in the MBT mechanics. It was also observed under some situation with the TMA wires (table no 3). The values obviously were high with 0.021"x 0.025" SS wires; but even with 0.018" X 0.025" SS high force values were noted (table no 3,4). This confirms the trends noted in the F.E.M study.

Table 2

ARCH WIRE	CENTRAL				LATERAL			CANINE		
	Displacement	SS	TMA	NiTi	SS	TMA	NiTi	SS	TMA	NiTi
0.018" X 0.025" AT 0, CT 0	3 mm	0.42		0.22	0.79		0.39	0.23		0.14
	5 mm	0.83		0.37						
0.018" X 0.025" AT 0, CT +7	3 mm	0.4		0.18	0.9		0.41	0.2		0.1
	5 mm	0.7		0.31				0.38		0.19
0.018" X 0.025" AT 0, CT -7	3 mm	0.46		0.26	0.36		0.24	0.3		0.19
	5 mm	0.94		0.38				0.78		0.27
	7 mm							1.22		0.55
0.018" X 0.025" AT 10, CT 0	3 mm	0.33			0.93			0.3		
	5 mm	0.84			0.01			0.63		
	7 mm	1.39								
0.018" X 0.025" AT 10, CT +7	3 mm	0.65			1.06			0.25		
	5 mm	1.22						0.43		
0.018" X 0.025" AT 10, CT -7	3 mm	0.45			0.49			0.64		
	5 mm	1						1.43		
	7 mm							1.98		
0.018" X 0.025" AT 15, CT 0	3 mm	0.62			1.01			0.59		
	5 mm	1.05			1.42			0.77		
0.018" X 0.025" AT 15, CT +7	3 mm	0.55			1.09			0.41		
	5 mm	0.93						0.67		
0.018" X 0.025" AT 15, CT -7	3 mm	0.56			0.46			0.32		
	5 mm	0.95						0.67		
	7 mm							1.19		
0.018" X 0.025" AT 20, CT 0	3 mm	0.61			0.97			0.31		
	5 mm	1								
0.018" X 0.025" AT 20, CT +7	3 mm	0.67			1.14			0.2		
	5 mm	1.13			1.62					
0.018" X 0.025" AT20, CT -7	3 mm	0.69			0.41			0.37		
	5 mm	1.09			0.7			0.83		
	7 mm							1.39		

All measurements are in Newtons

The figures highlighted in Red colour indicate generation of excess moment

*AT = Anterior torque in the wire

** CT = Torque in the Canine Bracket

In spite of all possible care and precautions, some human errors were inherent in the experiment. This was because the root apex position after elimination of wire bracket play had to be decided manually. Allowing a generous margin of 25% for such error, the force values, which were taken as high, were derived as follows. The upper limit of moments as accepted by almost all authors is 20 N-mm. The distances between the brackets of central incisor, lateral incisor and canine from the point of force attachment in our setup were

SUMMARY AND CONCLUSION

Our experimental study supports the F.E.M study[2] in the finding that abnormally high moments could be experienced by the lateral and central incisors if 0.019"x0.025" SS wires are directly employed for getting the roots of instanding lateral incisors labially torqued. This is particularly true when the canine bracket is having a +7° torque value. High moments are also likely with 0.018"x0.025" SS wires in some situations. The

0.017”x0.025” SS wires do not create abnormally large moments due to the play of the arch wire in the brackets.

Table: 3

ARCH WIRE	CENTRAL				LATERAL			CANINE		
	Displacement	SS	TMA	NiTi	SS	TMA	NiTi	SS	TMA	NiTi
0.019" X 0.025" AT 0, CT 0	3 mm	1.27	0.67	0.24	1.31	1.15	0.66	0.68	0.34	0.19
	5 mm	1.61	0.86	0.4				0.89	0.45	0.26
	7 mm	2.11	1.1	0.61						
0.019" X 0.025" AT 0, CT +7	3 mm	0.89	0.28	0.21	1.04	0.89	0.55	0.37	0.18	0.14
	5mm	1.4	0.43	0.3	1.88	1.35	1.07	0.68	0.26	0.2
	7 mm	1.75	0.71	0.48				0.97	0.48	0.29
0.019" X 0.025" AT 0, CT -7	3 mm	1.03	0.51	0.37	0.72	0.49	0.32	0.4	0.32	0.24
	5 mm	1.49	0.71	0.48	1.91			1.21	0.62	0.41
	7 mm	2.01	1.08	0.64				1.9	0.83	0.71
0.019" X 0.025" AT 10, CT 0	3 mm	0.99	0.43		1.26	0.95		0.65	0.16	
	5 mm	1.72	0.82					1.05	0.31	
	7 mm	2.16	1.32					1.43		
0.019" X 0.025" AT 10, CT +7	3 mm	0.92	0.39		1.83	1		0.49	0.1	
	5 mm	1.67	0.65					0.75	0.15	
	7 mm	2.12	0.98					1.03		
0.019" X 0.025" AT 10, CT -7	3 mm	1.03	0.54		0.98	0.36		0.4	0.23	
	5 mm	1.49	0.76		1.91	0.9		1.21	0.58	
	7 mm	2.01						1.9	0.97	
0.019" X 0.025" AT 15, CT 0	3 mm	0.74	0.28		1.21	1.09		0.47	0.26	
	5mm	1.26	0.52					1.12	0.54	
	7mm	1.96	0.92							
0.019" X 0.025" AT 15, CT +7	3 mm	0.89	0.39		1.25	0.99		0.44	0.22	
	5 mm	1.34	0.6					0.73	0.36	
	7 mm	2.12	1.11					0.95	0.52	
0.019" X 0.025" AT 15, CT -7	3 mm	0.79	0.48		0.66	0.68		0.37	0.17	
	5 mm	1.39	0.8					0.74	0.45	
	7 mm	2	1.16					1.72	0.94	
0.019" X 0.025" AT 20, CT 0	3 mm	0.88	0.48		1.21	0.71		0.41	0.22	
	5 mm	1.54	0.75					0.75	0.53	
	7 mm	1.85	0.96							
0.019" X 0.025" AT 20, CT +7	3 mm	0.75	0.39		1.2	0.52		0.52	0.23	
	5 mm	1.49	0.63		2.11			1.32	0.42	
	7 mm	2.03	0.94							
0.019" X 0.025" AT20, CT -7	3 mm	0.69	0.52		0.68	0.49		0.6	0.44	
	5 mm	1.27	0.77					1.33	0.88	
	7 mm	1.94	0.97					2.28	1.16	

All measurements are in Newtons

The figures highlighted in Red colour indicate generation of excess moment

*AT = Anterior torque in the wire

** CT = Torque in the Canine Bracket

Table : 4

ARCH WIRE	CENTRAL				LATERAL			CANINE		
	Displacement	SS	TMA	NiTi	SS	TMA	NiTi	SS	TMA	NiTi
0.021" X 0.025" AT 0, CT 0	3 mm	2.01		0.44	2.1		1.07	1		0.34
	5 mm	2.31		0.62				1.42		0.54
	7 mm	2.98		0.89				1.87		0.79
0.021" X 0.025" AT 0, CT +7	3 mm	1.21		0.37	1.33		0.81	0.55		0.23
	5mm	1.63		0.45	2.39		1.29	0.83		0.29
	7 mm	2.13		0.62				1.2		0.36
0.021" X 0.025" AT 0, CT -7	3 mm	1.26		0.57	1		0.56	0.64		0.37
	5 mm	1.79		0.71			0.29	1.48		0.55
	7 mm	2.25		0.89				2.25		0.83
0.021" X 0.025" AT 10, CT 0	3 mm	1.38			1.68			1		
	5 mm	2.06						1.34		
	7 mm	2.43						1.76		
0.021" X 0.025" AT 10, CT +7	3 mm	1.21			2.1			0.67		
	5 mm	1.97						0.99		
	7 mm	2.34						1.23		
0.021" X 0.025" AT 10, CT -7	3 mm	1.28			1.15			0.62		
	5 mm	1.7			2.19			1.41		
	7 mm	2.24						2.17		
0.021" X 0.025" AT 15, CT 0	3 mm	1.21			1.61			0.87		
	5mm	1.83						1.23		
	7mm	2.28						1.66		
0.021" X 0.025" AT 15, CT +7	3 mm	1.1			2.09			0.72		
	5 mm	1.79						1.29		
	7 mm	2.3						1.53		
0.021" X 0.025" AT 15, CT -7	3 mm	1.09			0.9			0.75		
	5 mm	1.55						1.49		
	7 mm	2.1						2.34		
0.021" X 0.025" AT 20, CT 0	3 mm	1.32			1.53			0.71		
	5 mm	1.82						0.98		
	7 mm	2.13								
0.021" X 0.025" AT 20, CT +7	3 mm	0.99			2.1			0.81		
	5 mm	1.72						1.53		
	7 mm	2.23						1.86		
0.021" X 0.025" AT20, CT -7	3 mm	0.89			0.85			0.84		
	5 mm	1.51						1.53		
	7 mm	2.17						2.52		

All measurements are in Newtons

The figures highlighted in Red colour indicate generation of excess moment

*AT = Anterior torque in the wire

** CT = Torque in the Canine Bracket

Hence the root inclination correction must be gradually done using succession of arch wires if SS wires are to be used. A safer approach would be to employ wires of low modulus initially such as the Ni-Ti or TMA and then employ the SS wires. This wire sequence will also be necessary if the labial root torque in the lateral incisor is lost mid way during the treatment because of bracket bonding failure. Or else, light auxiliaries could be employed for such correction.

When the upper lateral incisor is instanding, one should be very cautious in selecting the torque prescription for the adjacent canine tooth. If indicated, -7° bracket could be safely used. The next choice would be canine bracket with 0° torque. If it becomes inevitable to use the +7° torque bracket, the possibility of generating very high moments on the lateral incisor will have to be kept in mind all the time, and suitable measures will have to be adopted.

Since this was a novel study without any previous study to guide us in making a suitable experimental setup, we had to devise our own equipment. Under these circumstances, we could not employ any devices for measuring the moments directly. We had to depend on indirectly calculating the moments. Also, some margin had to be allowed for estimating the initial tooth positions. During force measurement, eliminating the wire bracket play involved subjective judgment. Because of all these factors, we could estimate the moment generation in a somewhat approximate fashion.

The experiment could be repeated with a more refined setup and using devices for measuring the moments directly.

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