REVIEW ARTICLE

Analysis of Orthodontic Prescriptions in Molars with Ideal Torque - a Laboratory Study

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Abstract

INTRODUCTION: There is a diverse range of orthodontic appliances available in clinical practice. However, there is also a lack of evidence regarding the effectiveness of different prescriptions on the final positioning of these teeth following rectangular strand insertion into orthodontic molar tubes. This study aimed to determine whether the torque present in the tubes of pre-adjusted devices of different prescriptions would alter the ideal inclination of the first and second lower and upper molars.

METHODS: This study utilized plaster models from 30 patients who presented with ideal torque. Four prescriptions with tubes of 0.22x0.028" slot were used: MBT, Roth, Damon, and Edgewise. Tubes were glued on to plaster models on the vestibular side of teeth in the center of the clinical crown. In addition to this gluing position, the position of 1 millimeter below the center of crowns on lower models was evaluated. Gaps between tubes and steel rectangular wires of 0.019x0.025"or 0.021x0.025" thickness were measured, and the effective torque was calculated from these values.

CONCLUSIONS: For 0.019x0.025" wires, a higher number of optimal torque maintenances was observed, regardless of the prescription tested, compared to 0.021x0.025" wires. The Roth prescription obtained the values closest to zero in the evaluation of the effective torque, indicating a small average torque change.

Keywords: Orthodontics; Dental models; Torque.

1. Introduction

Orthodontic treatments aim to obtain functional occlusions, dental and facial esthetics, and stable post treatment results. One of the criteria for obtaining a functional occlusion is the development of ideal vestibulo-lingual axial inclinations (torques) for all teeth by the end of active treatment.[1] The emergence of Edgewise appliances, developed by Edward H. Angle (1928), allowed for three-dimensional control of dental positions and, consequently, adequate control of torque by the end of treatment. Nevertheless, the effectiveness of these appliances depends on the manual skill of the professional in bending wires, which in turn implies an operator-dependent for the individualization of the case and correct finishing.[2]

To counteract these difficulties, Andrews developed the first fully preset orthodontic appliance (straight arch) in 1972, which accommodated for the angulation and inclination of dental crowns to brackets and tubes, thereby introducing features that could eliminate the need for forming first, second, and third-order bends in the orthodontic arch, which were previously necessary for the development of orthodontic treatments.[3]

However, what is observed in orthodontic practice is that the results may still fall short of expectations of the professional due to changes in the effective torque expression of prescriptions, even with the use of preset appliances. This occurs for several reasons, including inaccurate positioning of the bracket, the presence of a gap between the wire and the slot,[4] anatomical variations in the tooth surface and intermaxillary relationship, tissue recovery, biomechanical inefficiency of appliances, initial dental inclination, and manufacturing variations in bracket.[5,6,7,8]

Therefore, given the enormous variety of available prescriptions, the criteria that determine the selection of tubes and brackets are often subjective.[7] Orthodontists are confronted with different philosophies or approaches to treatment planning, with several options for performing certain dental movements and a varied amount of bracket models and prescriptions for dental positioning.[9]

Another factor that directly influences torque is the position in which the orthodontic accessory is glued to the tooth surface. It is not always possible to mount the accessory in the center of the clinical crown (for example in patients with deep overbite); when the tube is glued closer to the occlusal surface of the tooth, the torque expressed in the dental crown with the insertion of the rectangular wire is more vestibular, causing displacement of the tooth above the occlusal plane. Conversely, when the tube is glued closer to the cervical surface of the tooth, the expression of the torque with the insertion of the wire is more lingual, moving the tooth below the occlusal plane.[10]

To date, few studies have attempted to assess the interference of angles present in different prescriptions of preset appliances on molar torques.[8] The aim of this study was to compare the torque present in the tubes of preset instruments of different prescriptions, which may alter the ideal inclination (torque) of both lower and upper first and second molars.

2. Material and Methods

A laboratory, retrospective study was carried out using samples from patients evaluated for orthodontic treatment in a private clinic in the city of Cascavel, Paraná, Brazil. The research project was approved by the Research Ethics Committee (CEP), in accordance with Resolution No. 0181/09 of the National Council of the Ministry of Health, under the Opinion No. 2.254.475.

2.1. Samples

Plaster models were obtained from the archive of a private clinic in Cascavel, PR, Brazil. The initial study consisted of 730 models, of which 30 pairs that met the inclusion criteria were selected based on an equivalent study performed by Jain et al. (2013).

2.2. Inclusion/Exclusion Criteria

The models chosen were from patients aged 13-35 years who presented upper and lower first and second molars with good inclination (torque), evaluated using an American Board of Orthodontics (ABO) ruler. The degree of vestibular-lingual inclination is one of the occlusal criteria of the classification system for orthodontic models proposed by the ABO, which is considered the gold standard for the evaluation of plaster models of completed orthodontic treatments.[11] The models also needed to meet the following additional criteria: complete permanent dentition (absence of deciduous teeth), with the exception of third molars; presence of a planned or smooth curve of Spee; absence of interlocking tooth lines and restorations replacing the cusps or vestibular side of posterior teeth; fully erupted teeth without vestibular cavities; and absence of clinically perceptible occlusal abrasions.

2.3. Model duplications, bonding of tubes, and group composition

In order to preserve the original plaster models, the selected models were duplicated using a perforated tray (Morelli®, Sorocaba, SP, Brazil), molded with alginate (Jeltrade Plus®, Dentsplay, Petrópolis, Rio de Janeiro, Brazil), cast with gypsum (Asfer® type III, São Caetano do Sul, São Paulo, Brazil), and spatulated with a vacuum scalpel (Polidental®, Cotia, São Paulo, Brazil) following the manufacturers' recommendations for each procedure. Models were cut with the occlusal plane parallel to the ground, confirmed through a spirit level, in order to facilitate the standardization of angular measurements. In this sequence, convertible tubes of MBT, Roth, Edgewise (Morelli®, Sorocaba, SP, Brazil), and Damon (Ormco®, Glendora, California) prescriptions were bonded to models (Table 1), with a tube slot size of 0.022x 0.028".

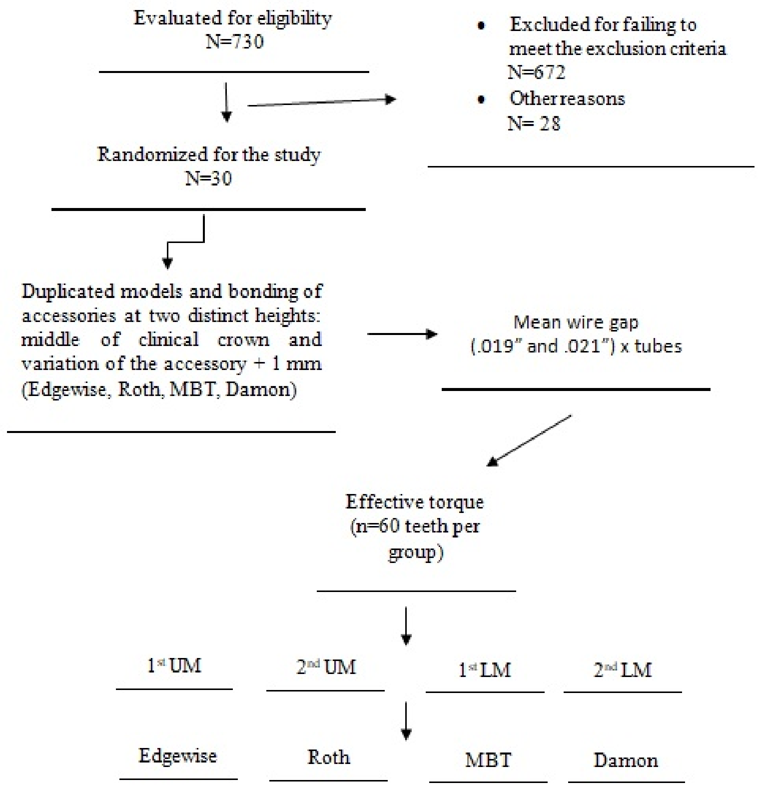
Table 1: Torque values by tooth for different prescriptions

Tooth/Prescription	Edgewise	Roth	MBT	Damon
1st Upper Molar	0°	-14°	-14°	-9°
2nd Upper Molar	0°	-14°	-14°	-9°
1st Lower Molar	0°	-30°	-20°	-30°
2nd Lower Molar	0°	-30°	-10°	-10°

Tubes for each prescription were randomly bonded by a previously trained and calibrated operator using a reverse orthodontic tweezer (Morelli®, Sorocaba, SP, Brazil) and cyanoacrylate (SuperBonder®, Itapevi, São Paulo). To avoid applying excess fluid, a drop was used at the base of the tube. The fittings were then placed at the center of the clinical crown,[12] followed by pressing for 5 seconds.

After defining this position, the other variation in the position of the accessory analyzed was the bonding of the tube one millimeter below the center of the clinical crown, in the gingival direction, also established by the digital caliper (Marberg®, São João de Meriti, Rio de Janeiro, Brazil). This evaluation was only performed in lower molars (Figure 1).

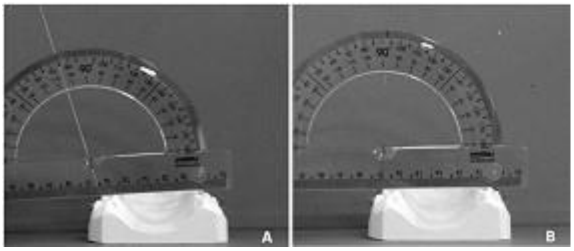
Figure 1: Flowchart of the distribution and dynamics of the groups.



2.4. Position and measurement of tooth/wire gap

An operator was trained and calibrated to measure the clearance between wires and tube slots. Steel wire thicknesses of 0.019x0.025" and 0.021x0.025" (Morelli, Sorocaba, SP, Brazil) were used. An L-shape fold at a 90° angle was made in 20 cm segments of wire using a pair of 442 pliers (Quinelato, Rio Claro, SP, Brazil). The L-segments of wires individually inserted into the tubes of plaster models positioned with occlusal surfaces facing upwards. Once inserted, the wire gap was observed in relation to the occlusal plane through a 180° protractor (Waleu, Diadema, SP, Brazil) and the extreme points of this gap in the vestibulo-lingual direction recorded (Figures 2A, 2B).[13]

Figure 2: The extreme point of this gap in the vestíbulo (A) and lingual (B) direction recorded.



2.4.1. Effective torque measurement

Once gap values were obtained, the effective torque of respective molar tubes was measured: if the 90° angle between the wire inserted in the tube and the occlusal plane of the molar was included in the upper and lower limits of the gap, it was agreed that the torque would be passive, with a value equal to zero; if the vestibular and lingual torque values were both altered in the same direction, below or above 90°, the vestibular or lingual value closer to 90° was selected, and the following calculation was made:

$$\boxed{\text{Effective torque} = 90° - \text{vestibular or lingual value closer to } 90°}$$

Thus, effective torque was obtained, with positive values indicating a vestibular movement of the tooth crown (vestibular torque), whereas negative values indicated lingual movement (lingual torque).

2.5. Statistical analyses

Prior to conducting comparative tests between groups, the normality of the effective torque data was assessed using the Lilliefors test. The data presented a non-normal distribution; thus, nonparametric variance analysis (Kruskal-Wallis) and a Dunn post-test were conducted. The comparisons were performed using the BioEstat 5.3 program (Mamirauá Institute, Belém, Pará, Brazil) with a 5% significance level.

To evaluate the reliability of torque measurements obtained with regard to the torque reading, new measurements for the same samples were performed after 1 month in the sample units of the models, in order to measure the error of the method. For effective torque, a random error of 1.26° was calculated, with a non-significant systematic error (paired t-test, p=0.303).

3. Results

3.1. Differences in torque for first upper molars

A similar trend first upper molars, specifically a torque change of a few degrees, was observed for the Roth, MBT and Damon prescriptions, for both 0.019x0.025"and 0.021x0.025" wires. However, the MBT prescription produced a lingual average change in average torque, whereas Damon and Roth prescriptions resulted in vestibular changes in torque (Table 2).

Table 3: Effective torque for 0.019x0.025"and 0.021x0.025" wires (degrees – mean value ± standard deviation) and inter-group comparisons between different wire thicknesses (letters) for first upper molars.

Prescription	1st UM Edge 19”	1st UM MBT 19”	1st UM Roth 19”	1st UM Damon 19”
Sample size	60	60	60	60
Arithmetic mean (standard deviation)	10.4000 A (7.4928)	-0.6167 C (3.8799)	1.8000 BCD (3.6675)	2.1667 D (8.0951)
	1st UM Edge 21”	**1st UM MBT 21”**	**1st UM Roth 21”**	**1st UM Damon 21”**
Arithmetic mean (standard deviation)	11.5333 A (7.4161)	-3.3333 C (5.5530)	2.5667 B (4.2401)	1.3167 B (5.8440)
	Different letters indicate statistically significant differences between the groups (Kruskal-Wallis, with Dunn’s post-test ($p<0.05$)			

3.2. Differences in torque for first lower molars

For first lower molars with tubes bonded 1 millimeter below the crown (+ 1 mm), we also observed a change in torque of a few degrees for the Roth, MBT, and Damon prescriptions, for both the 0.019x0.025" and 0.021 x0.025" wires. However, the average change in torque for the Damon + 1mm prescription was lingual, whereas changes in torque for both Roth and MBT were vestibular (Table 3).

Table 4: Effective torque for 0.019x0.025" and 0.021x0.025" wires (degrees – mean value ± standard deviation) and inter-group comparisons between different wire thicknesses (letters) for first lower molars.

Prescription	**1stLM Edge 19"**	**1stLM MBT 19"**	**1stLM Roth 19"**	**1stLM Damon 19"**	**1stLM +1 Edge 19"**	**1stLM +1 MBT 19"**	**1stLM +1 Roth 19"**	**1stLM +1 Damon 19"**
Sample size	60	60	60	60	60	60	60	60
Arithmetic mean (standard deviation)	33.3833 A (9.5351)	10.116 C (8.509)	6.9833 B (7.654)	5.2167 C (8.334)	22.9000 A (10.040)	3.2667 D (7.147)	1.8333 D (5.731)	-2.3500 D (10.265)
	1stLM Edge 21"	**1stLM MBT 21"**	**1stLM Roth 21"**	**1stLM Damon 21"**	**1stLM +1 Edge 21"**	**1stLM +1 MBT 21"**	**1stLM +1 Roth 21"**	**1stLM +1 Damon 21"**
Arithmetic mean (standard deviation)	36.3167 A (8.4382)	11.7500 BE (8.009)	8.3500 B (8.100)	4.5667 BC (7.284)	25.6333 A (7.3829)	2.5500 BCD (6.639)	0.2833 CD (5.430)	-3.0667 D (8.6864)
Different letters indicate statistically significant differences between groups (Kruskal-Wallis, with Dunn's post-test (p<0.05)								

3.3. Differences in torque for second upper molars

For the 0.019 x 0.025" wire in second upper molars, we observed a change of a few degrees from medium to lingual that was similar for both Roth and MBT prescriptions (Table 4). For the 0.021x0.025" wire, the Roth prescription demonstrated a lower tendency toward changes in torque.

Table 5: Effective torque of 0.019x0.025"and 0.021x0.025" wires (degrees – mean value ± standard deviation) and inter-group comparisons between different wire thicknesses (letters) for second upper molars.

Prescription	**2nd UM Edge 19"**	**2nd UM MBT 19"**	**2nd UM Roth19"**	**2nd UM Damon 19"**
Sample size	60	60	60	60
Arithmetic mean (standard deviation)	6.1500 A (6.3134)	-3.3000 B (5.3466)	0.3833 B (4.0967)	-14.6500 C (7.7849)
	2nd UM Edge 21"	**2nd UM MBT 21"**	**2nd UM Roth 21"**	**2nd UM Damon 21"**
Arithmetic mean (standard deviation)	8.2833 A (7.5219)	-6.5333 C (6.9611)	0.0167 B (4.6340)	-21.4833 D (7.3933)
Different letters indicate statistically significant differences between the groups (Kruskal-Wallis, with Dunn's post-test (p<0.05)				

3.4. Differences in torque for second lower molars

There were smaller changes in torque for the Roth and MBT prescriptions with tubes bonded 1 millimeter below the crown, for both wire thicknesses (Table 5). The average change in torque for both prescriptions was vestibular.

Table 6: Effective torque of 0.019x0.025" and 0.021x0.025" wires (degrees – mean value ± standard deviation) and inter-group comparisons between different wire thicknesses (letters) for second lower molars.

Prescription	**2nd LM Edge 19"**	**2nd LM MBT 19"**	**2nd LM Roth 19"**	**2nd LM Damon 19"**	**2nd LM +1 Edge 19"**	**2nd LM +1 MBT 19"**	**2nd LM +1 Roth 19"**	**2nd LM +1 Damon 19"**
Sample Size	60	60	60	60	60	60	60	60
Arithmetic mean (standard deviation)	40.5500 A (10.8416)	17.4667 BC (10.8557)	11.2833 BD (9.3828)	24.0833 C (15.2063)	27.5333 C (12.3871)	7.1333 D (9.4375)	5.5833 D (8.4016)	22.0167 C (12.7658)

	2nd LM Edge 21”	2nd LM MBT 21”	2nd LM Roth 21”	2nd LM Damon 21”	2nd LM +1 Edge 21”	2nd LM +1 MBT 21”	2nd LM +1 Roth 21”	2nd LM +1 Damon 21”
Arithmetic mean (standard deviation)	43.6167 A (9.8739)	18.8500 BC (9.8270)	14.2000 BD (9.6547	28.8667 E (13.4334)	30.400 E (10.3075)	7.4000 D (8.2405)	6.2333 D (8.8133)	26.1667 CE (12.0383)
Different letters indicate statistically significant differences between the groups (Kruskal-Wallis, with Dunn’s post-test (p<0.05)								

4. Discussion

For clinical orthodontists, limited evidence regarding the efficacy of molar tube torque, a large choice of prescriptions, and angulation variability in tubes[14,15] justify the need for further investigation into their effects on orthodontic prescription outcomes. In most clinical cases, compensatory folds in the rectangular wires are needed in the final stages of orthodontic treatment, irrespective of the prescription.[16,17] To address these issues, we selected models from patients with ideal molar torques and measured the torque of rectangular wires inserted in the tubes of standard Edgewise and preset appliances. Our aim was to determine if maintenance or alteration of the pre-existing torque in these teeth occurred with different prescriptions, and to quantify the magnitude of any changes.

Generally, previous studies evaluated and compared molar torque before and after treatment through a method originally proposed by Andrews (1972), which aimed to evaluate if the third occlusion key was obtained.[2,18] This study involved a reverse approach, in which the patients were selected because they presented excellent torque values for their first and second molars in accordance with the standards of the American Board of Orthodontics.[19]

We observed a large variability in torque readings for the same prescription, which was evident from high standard deviations and coefficients of variation between patients within the same treatment groups. This finding is consistent with those of previous studies[14,15] and possible explanations for this variation include anatomical variations in the height of the clinical crown, the shape of the dental arch, and the anatomy of the vestibular surface of teeth.[16,20,21,22,23]

With regard to effective torque estimated for the first upper molar, the Roth, MBT, and Damon prescriptions produced similar minor alterations. However, the relatively high standard deviations for these measurements indicate a lack of predictability for responses to different prescriptions and justify continuous monitoring by the orthodontist throughout the treatment period.[22,24,25]

For second upper molars, the Roth prescription resulted in a smaller average torque change (0.01º) with the 0.021 x 0.025" wire thickness. For0.019x0.02" wires, the MBT and Roth prescriptions presented the smallest values (-3.3º and 0.38º, respectively), with a tendency towards a lingual change in torque of the MBT prescription. Likewise, similarities between Roth and MBT prescriptions have been observed by other authors.[24,25] Notably, although both Roth and MBT prescriptions had torque values of -14º for upper molars, the angulation results differed between prescriptions. It was previously suggested that these variations in angulation are possibly due inadequate quality control during accessory manufacture.[20,26,27]

The vertical positioning of tubes influences final torque in molars.[10,22,27,28,29] This study simulated bonding of accessories closer to the cervical surface in inferior models, as this positioning is often necessary in clinical practice, especially for patients with a deep overbite. This adaptation would alter the prescribed torque, with the possibility of reaching up to 10º per millimeter of variation.[26,28]

For first lower molars, the prescriptions with effective torques that was closest to zero for both wire thicknesses were the Roth + 1mm, MBT + 1mm, and Damon + 1mm prescriptions. Notably, the Damon prescription had a tendency towards lingual torque changes, in contrast to the vestibular changes observed for the Roth and MBT prescriptions. For second lower molars, the Roth + 1 mm and MBT + 1 mm prescriptions resulted in smaller average changes in torque, both in the vestibular direction. Other authors, such as Ugur &Yukay (1997), did not find differences in torque between Edgewise or Roth prescriptions in relation to dental positioning of tubes. In this study, the Edgewise group was merely used as a control and no folds were used in the wires of this group; hence, we observed differences between these prescriptions.

4.1. Clinical Implications

Based on our findings, we concluded that there is no one prescription that is ideally suited to all molars. However, the Roth prescription generally presented the most frequent desirable results. These prescriptions were derived from normal occlusions or from previous clinical reports, and suggested torque values were obtained from previously reported mean values.[2,18,30] These recommendations should be applicable in most cases. However, as seen in this study, due to inherent variability between patients, there is a need for adjustment to prescriptions to suit individual cases, which can be achieved through folding of the rectangular wires to obtain ideal torque.[17,18]

5. Conclusion

The Roth prescription resulted in torque values closest to zero for all teeth.

For first lower molars, the Damon prescription resulted in an average torque change in the lingual direction, whereas the Roth and MBT prescriptions resulted in vestibular changes. For second lower molars, both Roth and MBT prescriptions resulted in smaller changes in torque in the cervical direction.

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