Journal of Research in Medical and Dental Science
2022, Volume 10, Issue 5, Page No:226-231

Available Online at: www.jrmds.in
eISSN No.2347-2367: pISSN No.2347-2545

Evaluation of Accuracy of Molar Band Slot Prescription and Torsional Play

Sruthi Harikrishnan*, Arvind Sivakumar

Department of Orthodontics, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai

ABSTRACT

Background: The molar buccal tube allows the arch wire to pass through while applying a torqueing force or allowing the wire to slide as tooth movement on the molar occurs. Despite proper molar band positioning, many orthodontists encounter issues such as buccal or lingual rolling in of molars, which can be caused by manufacturing defects in preformed molar bands that go unnoticed the majority of the time.

Aim: This study aims to evaluate the accuracy of molar band slot precision and their respective Torsional play.

Materials and methods: A sample of 45 first upper molar buccal tubes from three different Indian orthodontic manufacturers. The measurements of the first molar band dimension were performed using an optical microscope. The height and the width were measured on straight lines connecting the most external points of each side at three different sites and the average measurement of the three values was taken as the final measurement. The torsional play was calculated using the formula used by Joch in 2015.

Results: The highest theoretical mesial slot play was seen in group 1 and lowest in group 4. The highest theoretical distal slot play was seen in group 2 and lowest in group 3. One-way ANOVA showed statistically significant differences in the distal slot height (p-0.000) distal slot length (p-0.000) and distal slot play (p-0.001).

Conclusion: All the 3 Indian brand's molar tubes evaluated in this study had oversized slot lumens and loss of torque control during orthodontic treatment. So orthodontists using these brands should take extra caution and as when required should compensate for the anticipated torque loss with customization of arch wires, which necessitates additional chair time as well as total treatment time.

Key words: Torque, Molar tube, Microscope

HOW TO CITE THIS ARTICLE: Sruthi Harikrishnan, Arvind Sivakumar, Evaluation of Accuracy of Molar Band Slot Prescription and Torsional Play, J Res Med Dent Sci, 2022, 10 (5): 226-231.

Corresponding author: Sruthi Harikrishnan
E-mail:sruthident@gmail.com
Received: 21-Feb-2022, Manuscript No. JRMDS-22-50199;
Editor assigned: 23-Feb-2022, Pre QC No. JRMDS-22-50199 (PQ);
Reviewed: 9-Mar-2022, QC No. JRMDS-22-50199;
Revised: 22-Apr-2022, Manuscript No. JRMDS-22-50199 (R);
Published: 2-May-2022

INTRODUCTION

Orthodontic treatment mainly tries to achieve good facial aesthetics and stable occlusion. One of the key factors for a successful orthodontic treatment is the consistent application of appropriate biomechanics. To achieve optimal tooth positioning, the teeth must be properly positioned over their apical base. Appropriate axial crown and root inclinations are required to ensure proper occlusal function and to reduce relapse tendencies [1,2]. When straight-wire appliances are used, a satisfactory outcome is contingent upon a precise expression of the bracket's prescription, which is determined by the bracket's positioning, the arch wire's mechanical properties, and the slot's precision. The slot dimensional accuracy is critical to producing the prescribed three-dimensional tooth movements by delivering an optimized force between wire engagements within the respective slot. When the arch wire comes into contact with the bracket slot walls, it transmits first, second, and third-order information to the teeth. However, the actual position of the teeth at the end of orthodontic treatment frequently differs from what was expected, particularly in terms of dental inclination (torque) [3]. Torqueing force is used to achieve precise buccolingual root positioning, according to gnathologic concepts.

Torque can be defined in two ways: mechanically and clinically. Mechanically, it refers to arch wires twisting a structure about its longitudinal axis, which results in a twist angle. Torque is a rotational moment caused by shear. In orthodontics, it represents a tooth's buccal palatal crown/root inclination and is an orthodontic adaptation used to describe rotation around an x-axis. It describes the activation produced by twisting an arch wire in a bracket slot when used in an orthodontic arch wire/ bracket interaction. Orthodontists define torque around the dental arch in such a way that the x-axis follows the arch's curve. Torque in this context would be rotation perpendicular to the tooth's long axis [4,5]. Many factors have been shown to influence torque expressions such as Attachment designs, engagement angle of wire and slot, mode of ligation, attachment deformation, mechanical properties of wire, and wire edge bevelling are all declared as factors influencing the torque expression [6-8].

Most orthodontic treatment is performed with arch wires that are less than full-dimension, resulting in a lack of cohesive contact between the bracket and the wire; this is referred to as torsional play or the engagement angle [9]. This means that the clinician must use special measures to compensate for gaps in the system's information, such as finishing bends. The arch wire dimensions must coincide as closely as possible with those of the bracket slot to ensure complete transmission of information, particularly torque, from the appliance to the teeth.

Indeed, the greater the difference between the two, the more degrees of freedom the arch wire has (arch wire-slot play), and the lower the system's capacity to express the pre-programmed information [10]. Because of the play or free space in the bracket, not all of the torque is expressed when the wire passes through it. To express the required amount of torque, we can either use pliers to insert torque or torsion into the wire, or we can use a bracket with extra torque built in to account for the wire's amount of play. The amount of wire torsion or extra torque built into the bracket should be the same as the amount of wire play in the slot.

The molar buccal tube which forms the basic molar attachment of the edgewise appliance can be defined as a metal tube that is attached to the facial (buccal) surface of an orthodontic molar band or directly to the surface of the tooth and allows the arch wire to pass through while applying a torqueing force or allowing the wire to slide as tooth movement occurs [11-12]. The original tube was a 0.022-inch by 0.028-inch piece of gold or nickel silver tubing fused to the molar band [13]. Despite proper molar band positioning, many orthodontists encounter issues such as buccal or lingual rolling in of molars, which can be caused by manufacturing defects in preformed molar bands that go unnoticed the majority of the time [10]. This study aims to evaluate the accuracy of molar band slot precision and their respective Torsional play.

MATERIALS AND METHODS

This *in-vitro* cross-sectional study focuses on the upper first molar buccal tubes manufactured by three different Indian companies in which samples were tested to measure slot dimension and torsional play within the slot. The sample size was calculated using G*Power 3.1 (Franz Faul, University of Kiel, Germany) and was selected based on the mean scores obtained from Tepedino [14]. They had used the mean bracket slot dimensions for various brands as the primary outcome. The means and standard deviations of the three brand's bracket slot height (0.023 +/- 0.0006; 0.0224 +/- 0.0003; 0.022 +/- 0.003) were used for sample size calculation with an alpha error of 0.05, power of 0.95, and an allocation ratio of 1, for one way ANOVA, which resulted in a sample of 15 buccal tubes per group. A sample of 45 first upper molar buccal tubes from three different Indian orthodontic manufacturers was studied: every manufacturer provided 15 upper first molar bands. Arch wire dimensions of a 0.019*0.025 dimension SS wire (JJ Orthodontics Pvt. Ltd, Kerala) were measured using a considered standard digital verniercaliper. Upper first molar bands from the selected three different brands were grouped into three groups, Group 1 consisting of JJ molar bands (JJ Orthodontics Pvt. Ltd, Kerala, India), Group 2 consisting of Koden molar bands (KCK Dental Pvt. Ltd Calicut, India), Group 3 consisting of captain molar bands (Liberal Traders Pvt. Ltd. new Delhi, India). The bands from all three groups claimed to have a 0.022 × 0.028″ slot with McLaughlin-Bennett-Trevisi (MBT) prescription, with torque in base.

Optical microscopic analysis

The measurements of the first molar band dimension were performed using an optical microscope. Each molar band slot was placed vertically, with the mesial slot followed by the distal slot facing the microscope lens. While focusing on the mesial side, the distal side of the slot was assumed to be perfectly perpendicular to the observer. The optical microscope with an in-built camera was connected to scope software (scope tek Pvt ltd.) on a 1920 × 1080 pixels monitor (Figure 1). Screenshots of the slot were taken using the scope software and slot height and width were measured at three different locations as shown in Figure 1.

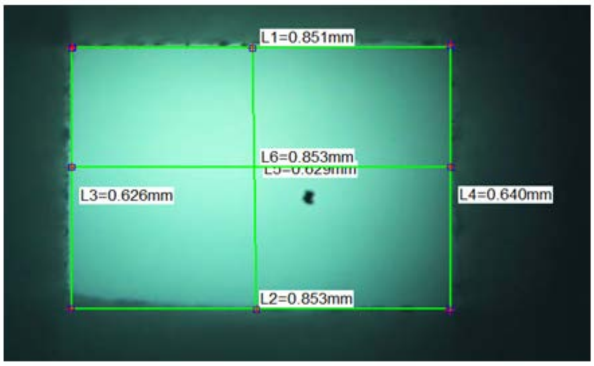

Figure 1: Mesial and distal slot dimension measured at three different locations on the live images of the slot.

Slot measurements

The height and the width were measured on a straight line connecting the most external points of each side at three different sites and the average measurement of the three values was taken as the final measurement.

Torsional play calculation

The torsional play was calculated using the formula used by Joch in 2015 [15].

$$Q=2^{*} \arctan \frac{b+(b^{2}-H^{2}+h^{2})^{1/2}}{H+h} \quad \text{-------- (1)}$$

Where,

H is the slot height,

b is the arch wire width,

h is the arch wire height,

Q is the torque play and t is the incorporated torque.

Torque play (Q) can be seen as the discrepancy between the size of the arch wire and the size of the bracket slot. Solving formula (1) for Q allows the calculation of the torque play from the arch wire and slot height dimensions using the following formula.

Statistical analysis

All data were collected and recorded on an Excel spreadsheet. Using parametric statistical analysis: descriptive statistics means and standard deviations were calculated for each parameter analysed in all three companies. The groups were compared using one way ANOVA using IBM SPSS software version 23. The level of significance was set at 0.05.

RESULTS

The mean average mesial slot height comparable to the ideal prescription was found in group 3 with an average height of 0.0245 inches. Comparable distal slot height was found in group 3 with an average height of 0.0215+0.0016 inches. Comparable mesial slot length was achieved in group 2 with an average length of .0326 inches. Comparable distal slot length was achieved in group 3 with an average length of .0300 inch (Table 1). The highest theoretical mesial slot play was seen in group 1 and lowest in group 4 (Table 1). The highest theoretical Distal slot play was seen in group 2 and lowest in group 3 (Table 1).

Table 1: Shows the Mean average Mesial and distal slot dimensions and their respective play among various groups.

Report							
Group		Mesial slot height	Mesial slot length	Mesial side play	Distal slot height	Distal slot length	Distal side play
GROUP 1	Mean	0.024832	0.032793	15.31007	0.022604	0.033332	8.836521
	N	10	10	10	10	10	10
	Std. Deviation	0.001595	0.003451	5.194413	0.000693	0.000848	1.84804
GROUP 2	Mean	0.024937	.0326.02451549	15.36202	0.023467	0.031168	11.13685
	N	10	10	10	10	10	10
	Std. Deviation	0.000484	0.000885	1.440495	0.000393	0.000713	1.089774
GROUP 3	Mean	0.024526	0.033646	14.13286	0.0215	0.030032	6.22019
	N	10	10	10	10	10	10
	Std. Deviation	0.000314	0.000405	0.932562	0.00165	0.001383	4.070924
Total	Mean	0.024765	0.033018	14.93498	0.022524	0.03151	8.731186
	N	30	30	30	30	30	30
	Std. Deviation	0.000961	0.002049	3.101747	0.001309	0.001707	3.277991

One-way ANOVA showed statistically significant differences in the distal slot height (p-0.000) distal slot length (p-0.000) and distal slot play (p-0.001) (Table 2).

Table 2: One way ANOVA comparing various parameters assessed between the groups.

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
Mesial slot height * group	Between Groups	(Combined)	0	2	0	0.475	0.627
	Within Groups		0	27	0		

	Total		0	29			
Mesial slot length * group	Between Groups	(Combined)	0	2	0	0.708	0.502
	Within Groups		0	27	0		
	Total		0	29			
Distal slot height * group	Between Groups	(Combined)	0	2	0	8.69	0.001
	Within Groups		0	27	0		
	Total		0	29			
Distal slot length * group	Between Groups	(Combined)	0	2	0	26.85	0
	Within Groups		0	27	0		
	Total		0	29			
Mesial side play * group	Between Groups	(Combined)	9.665	2	4.832	0.484	0.621
	Within Groups		269.34	27	9.976		
	Total		279.004	29			
Distal side play * group	Between Groups	(Combined)	121.034	2	60.517	8.574	0.001
	Within Groups		190.577	27	7.058		
	Total		311.611	29			

DISCUSSION

This *in-vitro* cross-sectional study was carried out to check for the dimensional accuracy of 3 different Indian brand molar tube bands and to their resultant torsional play for their use in everyday practice. In our study, we have found that dimensions of all three different manufacturers had oversized slot lumens as compared with the ADA prescribed standard. With the measured dimensions, we calculated the theoretical play. According to MBT prescription 19 × 25 ss wire in a 0.22 slot produces an ideal play of 9.6 degrees which none of our brands were able to achieve. One-way ANOVA showed that there was a significant difference between the 3 brands in terms of distal slot dimensions and play.

Several studies in the literature have demonstrated the effect of bracket slot and arch wire size variations on orthodontic treatment [16-23]. Most studies were done on the effect of bracket slot dimensional variation in anterior and premolar regions. The study by Kusy and Cash on bracket size showed that the bracket sizes were oversized up to 24% [19-21]. A study by Brown showed their bracket size to be undersized up to 20% [22]. Although there have not been many studies in the past, few studies have evaluated the dimensional accuracy of molar buccal tubes [24]. (Opal (Ultradent), Ormco (Damon), American Orthodontics and 3 M Unitek) and Al -Zubaidi [25] (Dentaurum (Dentaurum, Ispringen, Germany). 2-Forestadent (Forestadent, Pforzheim, Germany). 3-Ormco (Ormco, California, USA). 4-3 M (3 M Unitek, Monrovia, California, USA). 5-AO (American Orthodontics, Washington Avenue, Sheboygan, USA). 6-A-Star (A-star Orthodontics IncShanghai, China) analysed various brands' dimensional accuracy of buccal tubes and concluded that all of the companies they analysed produced oversized tubes. Our study also showed similar results with oversized bands. Figuereo study also concluded that all the analysed brands had convergent tubes. In our study slots were found to be divergent from mesial to distal aspect, since the distal slot dimensions were larger than the mesial slot dimension.

Archambault in a systematic review compared torsional play on the various prescription brackets and wires concluded that in a 0.022 slot with a 0.018 × 0.025-inch ss wire was 18 degrees and with a 0.021-0.025 inch arch wire it was 6 degrees [26]. Dellinger and Creek more in a 0.022-inch bracket slot with a 0.018, 0.025 inches stainless steel arch wire nominal play are 11.0217,14.818 and for a 0.021, 0.025 inch arch wire 1.7417, 3.918 respectively. Al- Zubaidi showed that the play is significantly associated with slot opening height [25]. According to MBT prescription 19 × 25 ss wire in a 0.22 slot produces an ideal play of 9.6 degrees which none of our brands were able to achieve. In our study, we calculated the theoretical play much higher than the ideal value.

A molar tube that is too small may cause friction during orthodontic space closure. The use of an oversized molar tube may result in excessive buccal or lingual inclination and marginal ridge discrepancies caused by improper expression of the prescribed tooth movements, including tip and torque. Resolving these negative outcomes necessitates the customization of arch wires, which necessitates additional chair time as well as total treatment time.

This study aimed to develop a novel approach for analysis and methodology in measuring the accuracy and quality of orthodontic brackets and molar buccal tubes. Limitation of this study include the use arch wires on a molar band than a bondable buccal tube which with the recent advancement have several benefits including increased efficiency due to the absence of separation, elimination of band spaces that may appear post-treatment, decreased contamination risks, foster placement, increased patient comfort, a more aesthetic appearance, decreased risk of decalcification associated with loose bands, and easier detection of caries due to increased visibility of the enamel. Variation in the total volume of the buccal tube due to the presence of irregularities was not evaluated. Other parameters such as the effect of bevel radius on the play were not analysed.

Further research with various dimensions of wires from various brands and other parameters such as bevel radius can be assessed. In this study dimensional accuracy was measured only on the mesial and distal ends; future research with cut tubes at the half and ¼ the length can be assessed. Furthermore, future research could look into the angle formed between the slot and the base, which determines the torque applied to a single tooth. Finally, this study only looked at these slot lumens' dimensional accuracy and integrity before they were put to use. Future research should be conducted to assess the precision, quality, and stability of bracket and tube slots over time to represent any changes that may occur as a result of the repeated insertion and removal of arch wires throughout treatment.

CONCLUSION

This study provides an easier approach for analysis for measuring the accuracy and quality of orthodontic brackets and molar buccal tubes and their play. All the 3 Indian brand's molar tubes evaluated in this study had oversized slot lumens and loss of torque control during orthodontic treatment. So orthodontists using these brands should take extra caution and as and when required should compensate for the anticipated torque loss with customization of arch wires, which necessitates additional chair time as well as total treatment time.

CONFLICT OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Andrews LF. The Straight-Wire Appliance. Br J Orthod 1979; 6:125-143.
2. R H Roth. The maintenance system and occlusal dynamics. 2021; 20:761-88.
3. Streva AM, Cotrim-Ferreira FA, Garib DG, et al. Are torque values of pre adjusted brackets precise. J Appl Oral Sci 2011; 19:313-317.
4. Andreasen GF, Amborn RM. Aligning, leveling, and torque control-a pilot study. Angle Orthod 1989; 59:51-60.
5. Archambault A, Lacoursiere R, Badawi H, et al. Torque expression in stainless steel orthodontic brackets A systematic review. Angle Orthod 2010; 80:201-201.
6. Morina E, Eliades T, Pandis N, et al. Torque expression of self-ligating brackets compared with conventional metallic, ceramic, and plastic brackets. Eur J Orthod 2008; 30:233-238.
7. Gioka C, Eliades T. Materials-induced variation in the torque expression of preadjusted appliances. Am J Orthod Dentofacial Orthop 2004; 125:323-328.
8. Sebanc J, Brantley WA, Pincsak JJ, et al. Variability of effective root torque as a function of edge bevel on orthodontic arch wires. Am J Orthod 1984; 86:43-51.
9. Meling TR, Odegaard J, Meling EO. On mechanical properties of square and rectangular stainless steel wires tested in torsion. Am J Orthod Dentofacial Orthop 1997; 111:310-320.
10. Johnson FW. Convertible buccal tube and Bracket. US Patent 9 1968; 3391416.
11. Angle EH. The Latest and Best in Orthodontic Mechanism. Dent Cosmos 1928; 70:1143-1158.
12. Tepedino M, Paiella G, Iancu Potrubacz M, et al. Dimensional variability of orthodontic slots and archwires: an analysis of torque expression and clinical implications. Prog Orthod 2020; 21:1-12.
13. Joch A, Pichelmayer M, Weiland F. Bracket slot and archwire dimensions: manufacturing precision and third-orderarchwires clearance. J Orthod 2010; 37:241–249.
14. Taylor NG, Ison K. Frictional resistance between orthodontic brackets and archwires in the buccal segments. Angle Orthod 1996; 66:215–222.
15. Siatkowski RE. Wear and tear from sliding mechanics. J Clin Orthod 1997; 31(12):812–13.
16. Siatkowski RE. Loss of anterior torque control due to variations in bracket slot and archwire dimensions. J Clin Orthod 1999; 33:508–510.
17. Kusy RP, Whitley JQ. Assessment of second-order clearances between orthodontic archwires and bracket slots *via* the critical contact angle for binding. Angle Orthod 1999; 69:71–80.
18. Kang B-S, Baek S-H, Mah J, et al. Three-dimensional relationship between the critical contact angle and the torque angle. Am J Orthod Dentofacial Orthop 2003; 123:64–73.
19. Cash AC, Good SA, Curtis RV, et al. An evaluation of slot size in orthodontic brackets—are standards as expected? Angle Orthod 2004; 74:450–453.
20. Brown P, Choi H, Pearce C, et al. Accuracy of Slot Dimension within Sets of Orthodontic Brackets. J Dent Res 2011; 90(997.1) [Google Scholar]
21. Meling TR, Odegaard J, Seqner D. On bracket slot height: a methodologic study. Am J Orthod Dentofacial Orthop. 1998; 113:387–393.
22. Figueroa SR. Accuracy of Slot Dimension within Sets of Orthodontic Buccal Tubes. Nova Southeastern University, Florida, United States 2013.
23. Al-Zubaidi HJ, Alhuwaizi AF. Molar Buccal Tubes Front and Back Openings Dimensions and Torsional Play. J Baghdad Coll Dent 2018; 30:32–39.

24. Archambault A, Lacoursiere R, Badawi H, et al. Torque expression in stainless steel orthodontic brackets. A systematic review. Angle Orthod 2010; 80:201–210.
25. Dellinger EL. A scientific assessment of the straight-wire appliance. Am J Orthod 1978; 73:290–299.
26. Zachrisson BU. Cause and prevention of injuries to teeth and supporting structures during orthodontic treatment. Am J Orthodontics 1976; 69:285–300.