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Assessment of dimensional accuracy of preadjusted metal injection molding orthodontic brackets

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ABSTRACT

Background: the aim of this study is to evaluate the dimensional accuracy of McLaughlin, Bennett, and Trevisi (MBT) brackets manufactured by two different companies (American Orthodontics and Ortho Organizers) and determine variations in incorporation of values in relation to tip and torque in these products.

Materials and Methods: In the present analytical/descriptive study, 64 maxillary right central brackets manufactured by two companies (American Orthodontics and Ortho Organizers) were selected randomly and evaluated for the accuracy of the values in relation to torque and angulation presented by the manufacturers. They were placed in a video measuring machine using special revolvers under them and were positioned in a manner so that the light beams would be directed on the floor of the slot without the slot walls being seen. Then, the software program of the same machine was used to determine the values of each bracket type. The means of measurements were determined for each sample and were analyzed with independent *t*-test and one-sample *t*-test.

Results: Based on the confidence interval, it can be concluded that at 95% probability, the means of tip angles of maxillary right central brackets of these two brands were 4.1–4.3° and the torque angles were 16.39–16.72°. The tips in these samples were at a range of 3.33–4.98°, and the torque was at a range of 15.22–18.48°.

Conclusion: In the present study, there were no significant differences in the angulation incorporated into the brackets from the two companies; however, they were significantly different from the ti*P* values for the MBT prescription. In relation to torque, there was a significant difference between the American Orthodontic brackets exhibited significant differences with the reported 17°, too.

Key Words: Appliance, orthodontic, prescription

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INTRODUCTION

One of the aims of orthodontic treatment is to reposition teeth to achieve optimal esthetic appearance and function. Clinicians have observed over the years that the type and design of brackets can have an important role in achieving this aim. It has been demonstrated that the bracket type affects the ultimate function and esthetic appearance.[1] On the other hand, the main factor with a great role in the success or failure and also in the duration

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of treatment is the application of correct forces to brackets and wires.[1] The conventional mechanical edgewise technique uses standard brackets, in which the orthodontist should use the archwire bends to control the position and movement of the teeth in all the three dimensions in space to bring about favorable tooth movements.[2-4] However, with advances in orthodontic appliances, Andrews developed the idea of incorporating internal angles into the design of orthodontic brackets and in 1972 introduced the preadjusted brackets; these brackets are referred to as straight wire systems due to less need for creating bends in the archwire for repositioning of teeth.[5-8] In the conventional mechanical edgewise technique, achieving the favorable position of the tooth at first, second, and third orders is brought about by creating in-out bends, tip, and production of a torque in the archwire, respectively; however, these aims in the straight wire system are achieved, respectively, by creating variations in the thickness of the base of the brackets, incorporation of angulation in the bracket slot, and creating a slope in the base to compensate the axial inclination of the facial aspect of the tooth that will have the advantage of decreasing patient visit times due to a decrease in need to apply the relevant bends in the archwire on the condition that they are effective.[9]

Andrews introduced 11 bracket types to this end.[5,6] Then, Roth introduced a single type of preadjusted brackets based on the problems encountered during clinical work.[10,11] Subsequently, various researchers introduced their specific bracket systems. For example, the McLaughlin, Bennett, and Trevisi (MBT) version was introduced by MBT with an aim to promote the status of the end of the treatment of patients.[12,13]

Although due to variations in the morphology of teeth and in responses to orthodontic forces creation of a real straight wire system is, in fact, possible only by personalizing the related values for each patient, it has been shown that orthodontists all over the world use these brackets extensively. For example, a study by Banks *et al*. showed that the majority of orthodontists in the UK use preadjusted brackets for the treatment of their patients.[14] The orthodontist should be aware of the characteristics of the brackets. Manufacturers in different countries market their brackets based on different prescriptions; however, are the values applied to them consistent with the values suggested by the manufacturers? A large number of researchers have expressed doubts about the validity of data reported by the manufacturers.[15-19] However, still no international standards have been determined for evaluating the quality and validity of these products. For example, it is not clear how much manufacturing errors are acceptable clinically in incorporating values into the brackets. In relation to a variable such as tip, for which there is a 1° difference in different prescriptions, it is not clear how much deviation from the related value is acceptable clinically in each prescription. The same is true in relation to torque, with the advent of the straight wire technique, the ideal buccolingual inclination was identified in teeth of esthetically pleasing smiles with Class I occlusions; this value was then incorporated into the bracket slot prescription. However, such a transfer assumes ideal materials, no torque loss due to slot design, accuracy of prescription with minimum deviation from actual and reported prescription values, and full expression of the prescribed value. Unfortunately, none of the foregoing assumptions are valid and the reason is that we deal with real materials, which possess various defects.[9,20] It is not clear whether the brackets are tested in relation to their overall accuracy and dimensional accuracy by independent researchers before they are marketed. Based on what was discussed above, the present study was designed to evaluate the dimensional accuracy of MBT brackets manufactured by two different companies and to determine variations in incorporation of values in relation to tip and torque in these products.

MATERIALS AND METHODS

In the present analytical/descriptive study, two preadjusted types of brackets with MBT prescription, manufactured by two different companies (American Orthodontics and Ortho Organizers), were evaluated for the accuracy of the values in relation to torque (buccolingual dimension) and angulation (mesiodistal dimension) presented by the manufacturers [Table 1].

From 50 brackets of each company, thirty-two maxillary right central brackets from each company were selected randomly. Each brand was designated the letter A or B, and this way the two operators were blinded to the brands. The operators had already been trained in how

Table 1: Brackets selected for the study

Bracket	Manufacturer	Tooth	Slot height (inch)	Tip	Torque
Master Series	American Orthodontics	1.1	0.022	4	17
Elite Opti-MIM	Ortho Organizers	1.1	0.022	4	17

to measure the angles and had been tested. The brackets underwent measurements in relation to the amount of angulation and torque as explained below.

To evaluate angulation, the brackets were placed in a video measuring machine (Automatic noncontact video measuring system, CAM series, ARCS Precision Technology Co., Taiwan) using special revolvers under them and were positioned in a manner so that the light beams would be directed on the floor of the slot without the occlusal and gingival walls being seen to avoid measurement errors that might occur due to improper positioning of the brackets [Figure 1].

Then, the software program of the same machine (CI-901 measuring software ARCS Precision Technology Co., Taiwan) was used to determine the values of each bracket type.

Two lines are required to calculate the tip: (1) mesiodistal axis of the slot and (2) occlusogingival axis of the bracket. The angle between these two axes is called α, and its difference with line perpendicular to the mesiodistal axis of the bracket shows the angulation of the bracket [Figure 2].

To determine the torque profile, the brackets were positioned with the use of the revolvers under them in a manner for the slot cross-section to be visible without the occlusogingival walls and the slot floor becoming visible. Then, the torque values are measured as shown in Figure 3.

The means of measurements were determined for each sample and reported as the final tip and final torque.

It should be pointed out that the accuracy of the measurements in this study to determine points was 0.003 μm, which might result in a maximum error of 6 min in the angle measured which is negligible.

The final measurements which were in degrees and minutes were converted to a fraction of a degree and analyzed with independent *t*-test between the groups using SPSS 17 (Chicago: SPSS Inc). One-sample *t*-test was used to compare the torque and ti*P* values reported in the MBT system between the two groups.

RESULTS

Analysis of data with independent *t*-test showed no significant differences in final tip between the two groups ($P = 0.454$). However, there was a significant difference in the final torque between the two groups ($P < 0.001$). One-sample *t*-test for the

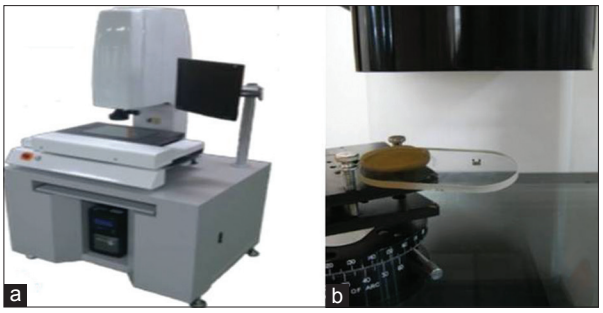

Figure 1: (a) Video measuring machine (automatic noncontact video measuring system, CAM series, ARCS Precision Technology Co., Taiwan). (b) Using special revolvers under the brackets for positioning them.

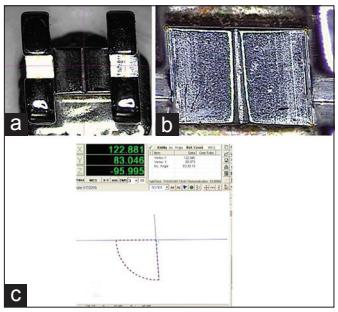

Figure 2: (a) To determine the mesiodistal axis of the slot in each wing, one point is specified on the intersection of occlusal and gingival walls of the slot with the bottom of the slot, points in the middle of these points are drawn in the occlusogingival dimension, and the mesiodistal axis of the slot is obtained when these points are connected. (b) To determine the longitudinal axis of the bracket, two points are specified on occlusal and gingival surfaces of the bottom of the slot on its joint with the inner wall of wings, their midpoints are drawn in the mesiodistal dimension, and the longitudinal axis of the bracket is obtained when these points are connected. (c) The angle between these two axes is called α, and its difference with line perpendicular to the mesiodistal axis of the bracket shows the angulation of the bracket.

comparison of the mean of final tip with a reported 4° value for MBT prescription showed a significant difference in the final tip with the constant 4° value ($P = 0.007$ in the American Orthodontic group and $P = 0.009$ in the Ortho Organizer group). There was a significant difference in the comparison of the final torque of American Orthodontic bracket with the consent value of 17 reported for MBT prescription ($P < 0.001$); however, Ortho Organizer did not exhibit a significant difference at the consent value of 17 ($P = 0.202$). Based on the confidence interval, it can be concluded that at 95% probability, the means of tip angles of maxillary right central brackets of these two brands were 4.1−4.3° and the torque angles were 16.39−16.72°. The tips in these

samples were at a range of 3.33−4.98°, and the torque was at a range of 15.22−18.48° [Table 2].

DISCUSSION

Since the different prescriptions of brackets have all been developed to decrease the need or avoid the need for first, second, and third order adjustments and achieve a straight wire technique, different companies have used these prescriptions for the manufacture of their preadjusted brackets. However, to achieve this aim, it is necessary to incorporate exact values of tip and torque within the brackets and it appears that it is necessary to determine international standards based on average size of teeth for favorable ranges of these values. A study to compare the slot angulation of the maxillary central and canine brackets from three different companies with the Roth prescription showed that the mesiodistal angulations were different between these three companies.[18] Another study in 2011 showed differences in torque and angulation values of MBT brackets marketed by different companies.[21] In another study, 4 bracket brands of Archist, Victory, Kosaka, and Confidence were evaluated in relation to the dimensional accuracy and manufacturing errors in angulation and torque. It was demonstrated that in relation to dimensional accuracy, there were no differences between the different products in the manufacturing errors of angulation. However, Confidence brackets exhibited significant differences in the manufacturing errors of torque.[19] Another study showed that even with the use of a similar wire, the brackets of different companies exhibited different play and torque functions, and in all the brackets evaluated, the dimensions of the slot were larger than those reported by the manufacturers,[22] which was similar to the results reported by Cash *et al*.[15]

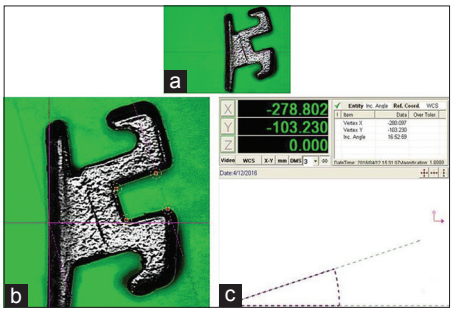

Figure 3: (a) Positioning the brackets in a manner for the slot cross-section to be visible without the occlusogingival walls and the slot floor becoming visible. (b) Four points are specified, 2 points on the occlusal wall and 2 points in front of them on gingival wall of the slot, then their midpoints are drawn and the line that divide the slot into half occlusogingivally is obtained when these points are connected. (c) Its angle with the line perpendicular to the line tangent to the base shows the inclination of the bracket.

In the present study, the minimum and maximum values of tip were recorded at 3.33° and 4.98°, respectively. The torque values were recorded at minimum and maximum of 15.22° and 18.48°, respectively. The question is whether the maxillary central bracket at 4.98° tip is acceptable for MBT prescription or not. Since this value is close to the 5° value reported for the Roth and Andrews systems, is a degree difference of over 1° in relation to the claimed torque acceptable in some samples? Since the tip and torque values depend on the interplay between the archwire and slot, which in turn depend on their geometry and size, whether such difference might be clinically considered important or not depends on the dimensions and geometry of the wire apart from the geometry and dimensions of the bracket. On the other hand, considering the fact that the values presented for each prescription are the mean favorable values by the researchers reporting them and the optimal values for each patient might

Table 2: The descriptive statistics of tip and torque incorporated into the McLaughlin, Bennett, and Trevisi bracket systems from American Orthodontic and Ortho Organizer companies

	Mean	SD	SE	95% CI for mean		Minimum	Maximum
				Lower bond	Upper bond		
Final torque							
American Orthodontics	16.23	0.62	0.11	16.00	16.46	15.22	17.28
Ortho Organizers	16.88	0.49	0.08	16.70	17.06	16.25	18.48
Total	16.56	0.64	0.08	16.39	16.72	15.22	18.48
Final tip							
American Orthodontics	4.17	0.33	0.05	4.05	4.29	3.60	4.82
Ortho Organizers	4.24	0.46	0.08	4.08	4.41	3.33	4.98
Total	4.29	0.39	0.04	4.10	4.30	3.33	4.98

SD: Standard deviation; SE: Standard error; CI: Confidence interval

be different depending on the amatory of their teeth and their facial characteristics, the optimal range of these values are different in different patients. However, since accurate selection of a bracket and its correct positioning might facilitate the treatment process, it is important that after determining the related standards, studies are carried out by independent researchers to evaluate the quality of the products of different companies before marketing them to confirm their dimensional accuracy and the acceptable range of manufacturing errors in them for the relevant population. Finally, this is the orthodontist who will decide which available bracket with what accuracy will be suitable for the treatment of his/her patients after he/she gains proper knowledge about the properties of the products. In view of earlier discussions and the obtained results, it is necessary that international standards should be defined for an acceptable level of fabrication errors and premarket quality evaluation for these products. Thus, a precise and repeatable technique is required in surveys to measure their dimensional accuracy as improper and imprecise positioning can increase potential for measurement errors. Therefore, it is recommended that brackets are positioned such that the measurable surface area at microscopic scale would be completely parallel to the measuring tools as even a slight angle between them can cause errors in calculating the angles. To this end, brackets should be positioned in such a way that occlusal and gingival slot walls are not visible in the respective section, similar to the present study.

CONCLUSION

There were no significant differences in the angulation incorporated into the brackets from the two companies; however, they were significantly different from the ti P values for the MBT prescription. In relation to torque, there was a significant difference between the American Orthodontic brackets exhibited significant differences with the reported 17°, too.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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