



EVALUATION AND COMPARISON OF VARIOUS PRESCRIPTION SPECIFICATIONS AND SLOT DISTORTION OF PRE-ADJUSTED EDGEWISE BRACKETS MANUFACTURED BY DIFFERENT COMPANIES AVAILABLE IN INDIA

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ABSTRACT

Objective: To assess and evaluate the tip, torque, slot size & slot distortion of maxillary central incisor, maxillary lateral incisor & maxillary canine brackets from commercially available bracket systems (Agile Mini Brackets- 3M series, Mini series- American Orthodontics, Mini Gem series- Dento Smile, Fine Series Brackets - Galaxy Orthodontics, Centrino Mini brackets- Libral trader, Orthox Organizers) in the 0.022-inch dimension.

Material & method: The sample consisted of three brackets each (maxillary central incisor, lateral incisor & canine) of all the companies the tip, torque & slot dimension of which were measured in the 0.022-inch dimension. Images were obtained using stereomicroscope & measurements were taken after operator calibration using AUJTOCAD software 2012, and a digital readout was produced.

Results: Results indicated that none of the companies showed exact values of tip & torque however 3M Agile Mini series showed values nearest to normal whereas Orthox Organizers showed most inaccurate values. For slot dimension American Orthodontics Mini series showed most accurate values whereas Orthox Organizers showed most inaccurate values. All the companies showed oversized slot except Dento Smile Mini Gem series which showed undersized slot. Slot distortion was found maximum in Orthox Organizer & least in American Orthodontics Mini series.

Conclusion: Inaccuracy in slot dimension, inbuilt tip and torque of the pre-adjusted brackets can affect the final position of teeth in the arch with an added need of wire bending to achieve desired results.

Key Words: Tip, Torque, Slot size, Slot distortion

INTRODUCTION

Orthodontic treatment objectives can be stated as obtaining functional occlusion, esthetics and stability. One of the criteria for obtaining a functional occlusion is to have an ideal axial inclination of all teeth at the end of active treatment. The advent of sophisticated appliances and materials has helped to raise the standard of orthodontic treatment, and as a consequence achieving ideal occlusion has become a realistic aim. Over the years, clinicians have considered how bracket design can help achieve these objectives.¹

Andrews made extensive measurements on untreated excellent occlusions.² Before the Straight Wire Appliance

came into existence, the teeth were moved on their apical base in three plane of space by incorporating bends in the wire. With the SWA these features were inbuilt into the brackets. The tip was incorporated by angulating the bracket wing in mesiodistal plane. The torque was incorporated initially by angulating the base (Torque in base) & later by angulating the face (Torque in face). The concept behind this SWA was that for a given slot dimension, when a working wire is placed into the slot this inbuilt tip & torque starts getting expressed with minimum requirement of wire bending.

The on-going appliance evolution resulted in two orthodontic bracket slot sizes that a clinician may choose to use when correcting a patient's malocclusion. These two

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dimensions, 0.018 inch and 0.022 inch, are separated by four thousandths of an inch. The 0.022-inch slot was the first to be introduced, and this suited the gold wires that were used either singly or in a twinned configuration. The slot dimension dichotomy is yet to be resolved because modern wires are probably equally effective in both the 0.022 and the 0.018-inch slots. As a result, several authors have called for construction of a new breed of orthodontic brackets in metric dimensions.^{3,4}

The orthodontic bracket receives force from an activated element –usually a wire & transmits that force to the tooth. If the bracket fractures or permanently deforms, the force is not transmitted & treatment is prolonged. These forces are created as a result of the intimate fit of wire into the bracket slot and any “play” or “slop” between these components will result in incomplete transmission of the bracket prescription to the tooth and its supporting tissues. Torquing force moments are most often obtained during the course of orthodontic treatment through a force couple generated by the torsion of a rectangular archwire in a rectangular bracket slot. Many factors have been found or thought to affect torque expression namely torsion magnitude, wire composition, torsional stiffness, wire dimension, slot dimension, wire/bracket slot play, tooth inclination, interbracket width (wire length) and bracket deformability⁵. Accurately measuring and predicting torque expression and understanding the sources of torque loss are critical for providing predictable orthodontic treatment results.

This study aims to evaluate & compare the efficacy of the prescription specification, slot size and bracket deformation when torque is applied through the use of a wire in six commercially available orthodontic bracket system with the 0.022-inch dimension.

MATERIALS & METHOD

The present study was carried out in the Department of Orthodontics & Dentofacial Orthopaedics, Sharad Pawar Dental College, Datta Meghe Institute of Medical Science (Deemed University), Wardha, Maharashtra in co-ordination with Department of Oral Pathology, Sharad Pawar Dental College, with the technical assistance from the Department of Mechanical Engineering, Visvesvaraya National Institute of Technology, Nagpur.

1. Maxillary right central incisor, lateral incisor & canine brackets of MBT prescription with 0.022” slot of six commercially available conventional system were selected for comparison which were grouped as

Group 1- Agile Mini Brackets- 3M series

Group 2- Mini series- American Orthodontics

Group 3- Mini Gem series- Dento Smile

Group 4- Fine Series Brackets - Galaxy Orthodontics

Group 5 -Centrino Mini brackets- Libral traders

Group 6– Orthox Organizers

For assessment & comparison of tip, torque & slot dimension values for maxillary anterior brackets (maxillary right central incisor, lateral incisor & canine), they were coded to avoid operator bias. For calculation of tip of the brackets, facial view of the brackets was scanned under Stereomicroscope with 10X magnification. The obtained images were then calibrated using AUTO CAD software 2012. The tip of the bracket was calculated by measuring the angle between long axis of the bracket & horizontal line connecting the lower border of the upper wings. The complementary angle of the value obtained was the tip of the bracket. (Figure1).

For calculation of torque & slot dimension, the lateral view of the brackets was scanned under Stereomicroscope with 10X magnification. The obtained images were then calibrated using AUTO CAD software (2012) & the torque of the bracket was calculated by measuring the angle between long axis of the bracket base & long axis of the slot base. (Figure 2)

The slot dimension was calculated by drawing a line within the slot parallel to the slot base & measuring the linear distance between two selected points on which the line was drawn. (Figure2). The height of the slot was calculated & a normal 0.022” bracket slot height when converted into millimetres is equal to 0.56mm which was taken as the control group for slot dimension.

The brackets were then adhered to the maxillary models in their standard position using cyanoacrylate adhesive. Total six models were prepared & a 0.019” × 0.025” S.S archwire for each model was then given a palatal torque of 16° using a torquing turret. (Leone group)

The wire was placed onto the bracket assembly of each model & secured using elastomeric modules. On one end of the wire that passed through the brackets, stepper motor was attached for sliding the wire & the other free end was tied with the load of 100gm. The wire was slid through the bracket with the velocity of 0.05mm/min & the load cell deflection was noted on digital indicator. Same procedure was repeated for every group.

After the sliding of the wire, the maxillary anterior brackets were again scanned under Stereomicroscope & the slot dimension was calculated using AUTO CAD software. 2012 (figure 3)

RESULTS

A comparison of three operators` calibration was done on 5mm scale in an AUTOCAD 2012 software. One sam-

ple t-test was performed for all brackets measurements for tip, torque & slot size. For Central Incisor the mean values of tip (Table No.1) were found to be for Group 1(4.33°), Group 2(6.00°), Group 3(5.67°), Group 4(5.00°), Group 5(4.66°), Group 6(1.67°) (P<0.05). For Lateral Incisor the mean values of tip(Table No.1) were found to be for Group 1(7.67°), Group 2(9.33°), Group 3(7.33°), Group 4(5.33°), Group 5(8.33°), Group 6(10.67°) (P<0.05). For Canine the mean values of tip(Table No.1) were found to be for Group 1(8.33°), Group 2(7.67°), Group 3(7.00°), Group 4(7.33°), Group 5(7.67°), Group 6(5.67°).

For Central Incisor the mean values of torque(Table No.2) were found to be for Group 1(17.67°), Group 2(12.67°), Group 3(22.67°) (P<0.05), Group 4(11.67°) (P<0.05), Group 5(17.67°), Group 6(7.67°). For Lateral Incisor the mean values of torque (Table No.2) were found to be for Group 1(10.33°), Group 2(9.33°), Group 3(8.33°) (P<0.05), Group 4(13.33°) (P<0.05), Group 5(4.33°) (P<0.05), Group 6(6.33°) (P<0.05). For Canine the mean values of torque(Table No.2) for Group 1(-4.33°) (P<0.05), Group 2(-1.67°) (P<0.05), Group 3(-8.33°), Group 4(-12.67°) (P<0.05), Group 5(-11.33°) (P<0.05), Group 6 (-9.00).

For Central Incisor the mean values of slot dimension (in mm) (Table No.3) were found to be for Group 1(0.66) (P<0.05), Group 2(0.57), Group 3(0.54), Group 4(0.57), Group 5(0.62) (P<0.05), Group 6(0.60) (P<0.05). For Lateral Incisor the mean values of slot dimension (in mm) (Table No.3) were found to be for Group 1(0.62) (P<0.05), Group 2(0.54), Group 3(0.54), Group 4(0.56), Group 5(0.61) (P<0.05), Group 6(0.65) (P<0.05). For Canine the mean values of slot dimension (in mm) (Table No.3) were found to be for Group 1(0.67) (P<0.05), Group 2(0.57), Group 3(0.54), Group 4(0.59) (P<0.05), Group 5(0.62) (P<0.05), Group 6(0.60) (P<0.05). All brackets size examined were oversized except Dento Smile Mini Gem series which were undersized.

For Central Incisor the slot distortion(Table No.4) were found to be for Group 1(4.61%), Group 2(0%), Group 3(11.11%), Group 4(7.01%), Group 5(6.56%), Group 6 (13.33%) when compared to the original slot dimension. For Lateral Incisor the slot distortion(Table No.4) were found to be for Group 1(4.83%), Group 2(1.85%), Group 3(12.96%), Group 4(7.14%), Group 5(6.55%), Group 6 (10.71%) when compared to the original slot dimension. For Canine the slot distortion (Table No.4) were found to be for Group 1(4.47%), Group 2(1.75%), Group 3(7.40%), Group 4(3.38%), Group 5(4.83%), Group 6 (10%) when compared to the original slot dimension.

DISCUSSION

During orthodontic treatment, complex combinations of linear forces, moments & couples are developed by the arch wire. These moments are expressed in three planes of space. The current study focussed on evaluating the efficacy of MBT prescription of various companies commonly used i.e. the inbuilt tip, torque & stated slot dimension along with the slot distortion when a torqued wire placed is slid through the brackets.

From the above findings it can be deduced that although no company had an exact tip for any of the three brackets, the Group1 showed the most consistent accurate findings & Group 6 was the least accurate among all the companies for the tip of all the brackets. The possible reason for a wide range in tip values of pre-adjusted orthodontic brackets could be the manufacturing error. The two variables, the angle between which determines the tip of the bracket are long axis of the bracket represented by a vertical slot & a line connecting lower border of upper wings or upper border of lower wings. The slight angulation of the wings of the bracket with respect to the long axis of the bracket determines the inbuilt tip of the bracket. So any variation in the vertical orientation of wings with respect to each other can alter tip of the bracket. This can be attributed to different manufacturing processes such as injection molding, grinding & machining techniques.

The result of our study was in contrast to that by Raghuraj et al⁶ who evaluated the efficacy of the MBT appliance 0.022" prescription in expressing inbuilt tip and torque values using torque angulation device & found that the discrepancy in tip expression was only 1° & it was expressed better than the torque.

The significance of 2nd order (Tip) & its effect on torque was studied by Meiling et al⁷ who concluded that application of a second order couple (tip) to a longitudinally twisted arch wire will set up third order couple & this couple will have a restraining effect on the third order wire-bracket interaction.

For torque, from the above findings it can be deduced that although no company had an exact torque for any of the three brackets, the Group 1 showed the most consistent accurate findings & Group 6 was the least accurate among all the companies for the torque of all the brackets.

The possible reason for a wide range in torque values of pre-adjusted orthodontic brackets could be the manufacturing error in the alignment of slot base & bracket base. . If the slot base is not accurately aligned during the manufacturing process of injection molding, casting or milling i.e. mold for the slot base is not accurately aligned, the die for the slot base will be reproduced inaccurately resulting in change in the angle between base &

face ultimately changing the torque value of the bracket.

Aditya et al⁸ evaluated the torque accuracy of MBT prescription 0.022" slot using SEM & found results similar to our study. 5 preadjusted metal 0.022" bracket with standard MBT prescription with Agile Abzil brand (3M Unitek) , MBT Ormco & Versaden were evaluated. The mean torque angle of bracket Agile brand 3M Unitek & Versaden showed a smaller no. of large torque angle, while Ormco bracket torque angle showed greater than the angle of the MBT prescription torque. This shows a large discrepancy torque angle bracket Agile brand 3M Unitek , Versaden & Ormco which are similar to the findings of our study.

The results of Raghuraj et al⁶ were similar to the results obtained in our study. He evaluated the efficacy of the MBT appliance in expressing inbuilt tip and torque values using torque angulation device & found that Torque was over expressed in maxillary- lateral incisor, canine and mandibular-central, lateral incisor and canine.

For slot size, Group 3 for Central Incisor & Canine showed undersized slot, Group 4 for Lateral Incisor showed exact slot dimension but all the other groups showed an oversized slot.

The possible reason for this variation can be the various types of manufacturing process i.e. injection molding, casting or milling which affects the accuracy of prescribed torque values. Molding exposes the material to expansion & shrinkage; milling can incorporate a rough grained surface. Shrinkage defects with casting occur when standard feed metal is not available to compensate for shrinkage as the thick metal solidifies.

Kusy & Whitley⁹ examined 24 brackets from eight manufacturers & found three bracket slots smaller & 20 others larger than the dimension stated by their manufacturers. The largest 0.018inch slot measured 16% larger than stated and largest 0.022inch slot measured 8% larger than the stated. The variation in slot size found in this study was similar to that found in our study.

The study by Cash et al¹⁰ also showed similar findings to that of our study. The slots of five upper left central incisor brackets from 11 commercially available bracket systems were measured in the 0.022-inch (0.5588 mm) dimension. Results indicated that all bracket slots were oversized.

For slot distortion, from the above findings it can be deducted that Group 2 proved to be most resistant to slot distortion when a torqued wire was slid & Group 6 showed maximum amount of distortion.

The possible reason for variation in the amount of slot distortion in different companies with the same amount of torquing force can be the inaccuracy of the manufac-

turing process. The same raw material used (stainless steel) with different process can exhibit different mechanical properties. Casting process & injection molding if not done under adequate compression can result in internal gaseous porosity of the metal. This internal void weakens the microstructure of the metal making it more prone to deform. Milling process also imparts roughness & surface irregularities to the bracket. This results in a lot of friction on the bracket-wire interface. Stress concentration on this area also causes the slot to deform.

Group 3 also showed a remarkable amount of slot distortion. This can be correlated with the fact that Group 3 had an undersized slot. So the amount of play between a 0.019"×0.025" SS wire & a 0.022" slot is reduced. There is less freedom of movement of the wire in the slot & more binding & stress concentration in the bracket slot. This can also be a probable reason for slot distortion in Group 3.

Daniel Flores et al¹¹ did a comparative study on deformation of metal brackets & found similar results as obtained in our study. The purpose of this study was to determine the effect of material & design on the force & stress required to permanently deform metal brackets. Results showed that 17-4PH & 303S had higher yield strength & regular twin brackets had a higher resistance to deformation. Also, as a slot torque degree increased, brackets deformed with less force.

Kapur et al¹² compared load transmission & bracket deformation between titanium & stainless steel brackets & found similar results. Both 0.018 and 0.022 inch slot size edgewise brackets were tested in a specially designed apparatus that applied a torque value of 45°. The load generated was measured by an Instron Universal Testing Machine at intervals of 15°, 30°, and 45° of torque application. The structural stability of the brackets was evaluated by measuring the bracket slot width with a travelling stereoscopic microscope before and after the brackets were subjected to torsional forces.. The titanium brackets transmitted higher loads at 15° and 30° torque and lower load at 45° torque on application of torsional forces in comparison to stainless steel brackets. The titanium brackets demonstrated superior dimensional stability compared to stainless steel brackets.

Lacoursiere et al¹³ measured orthodontic bracket tie wing elastic & plastic deformation by arch wire torque expression utilizing an optical image correlation technique. Ormco Orthos 0.022" (0.56mm) slot stainless steel upper right central incisor brackets with a 15-degree prescription and Ormco 0.019" × 0.025" stainless steel wires (Ormco Corporation,) combination was used. The torque expression jig which was added to an existing single axis torsion device was used. This experimental working confirmed anecdotal evidence that the bracket tie wings undergo elastic deformation when loaded.

Orthodontic clinicians should be aware that the pre-adjusted bracket and wire systems widely used in clinical practice may not produce the three-dimensional control required to produce an acceptable result. This may be particularly evident in cases that require incisor inclination correction, and the clinician should be aware that additional root torque may have to be added to the upper incisors to overcome inaccurate manufacturing dimensions. This clearly reduces the simplicity and effectiveness of a straightwire, preadjusted system and may encourage a clinician to favor the use of zero-base edgewise style treatments.

A clinician, unhappy with a bracket and wire system that consistently produces over retraction of the incisors, may attempt to circumvent this problem by using a preprogrammed bracket system with increased incisor torque values. This may be a way around the problem, but it would seem logical that bracket systems will only reproducibly produce their prescription when slots and wires are as intimately fitting as is clinically practical and possible to guarantee by the manufacturers.

CONCLUSION

The results of this study indicate that none of the companies of pre-adjusted appliance MBT prescription showed exact values of tip, torque & slot size along with significant amount of slot distortion which necessitates the need of wire bending for a technique which is called as Straight wire technique for full expression of tip & torque. Tip, torque and the slot size varied greatly between the bracket groups.

Disclaimer`s note- This study does not intend to promote any product but is a genuine research to give an insight of the amount of variations present in a particular brand from the normal so that the clinicians are aware of the manufacturing errors & that they can take proper measures to counteract those errors clinically.

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Table 1: Values of Tip

Brackets	3M Agile Mini series	American Orthodontics Mini series	Dento Smile Fine series	Galaxy Orthodontics Fine series	Libral Centrino Mini brackets	Orthox Organizers
Central Incisor (Normal value= 4°)	4.33	6.00	5.67	5.00	4.66	1.67*
Lateral Incisor (Normal value= 8°)	7.67	9.33	7.33	5.33	8.33	10.67*
Canine (Normal value= 8°)	8.33	7.67	7.00	7.33	7.67	5.67*

Table 2: Values of Torque

Brackets	3M Agile Mini series	American Orthodontics Mini series	Dento Smile Fine series	Galaxy Orthodontics Fine series	Libral Centrino Mini brackets	Orthox Organizers
Central Incisor (Normal value= 17°)	17.67	12.67	22.67*	11.67*	17.67	7.67
Lateral Incisor (Normal value= 10°)	10.33	9.33	8.33*	13.33*	4.33*	6.33*
Canine (Normal value= -7°)	-4.33*	-1.67*	-8.33	-12.67*	-11.33*	-9.00

Table 3: Values of Slot dimension

Brackets	3M Agile Mini series	American Orthodontics Mini series	Dento Smile Fine series	Galaxy Orthodontics Fine series	Libral Centrino Mini brackets	Orthox Organizers
Central Incisor (Normal value= 0.56mm)	0.66*	0.57	0.54	0.57	0.62*	0.60*
Lateral Incisor (Normal value= 0.56mm)	0.62*	0.54	0.54	0.56	0.61*	0.65*
Canine (Normal value= 0.56mm)	0.67*	0.57	0.54	0.59*	0.62*	0.60*

Table 4: Values of Slot distortion

Brackets	3M Agile Mini series	American Orthodontics Mini series	Dento Smile Fine series	Galaxy Orthodontics Fine series	Libral Centrino Mini brackets	Orthox Organizers
Central Incisor (in %)	4.61	0	11.11	7.01	6.56	13.33
Lateral Incisor (in %)	4.83	1.85	12.96	7.14	6.55	10.71
Canine (in %)	4.47	1.75	7.40	3.38	4.38	10

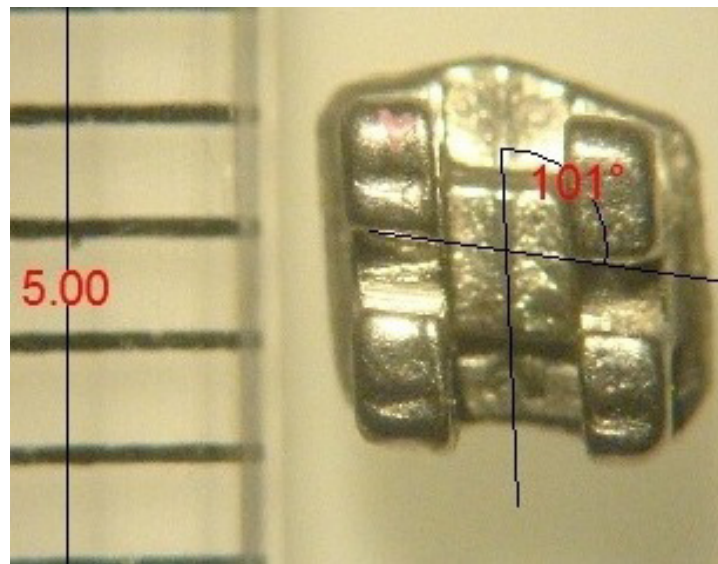


Figure 1: Calculation of Tip

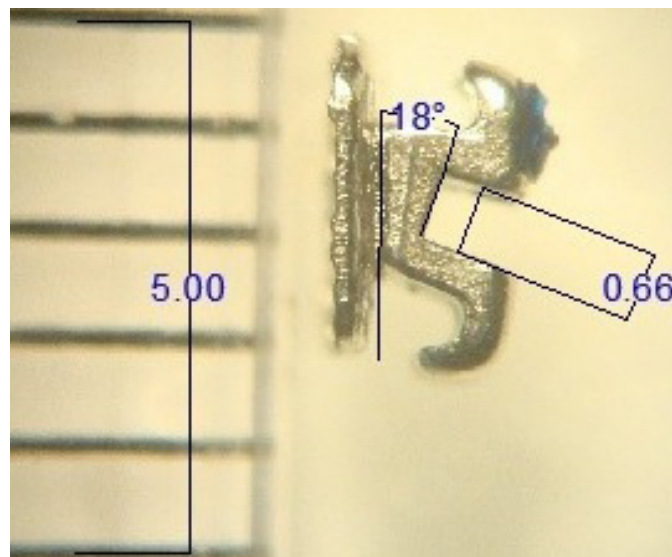


Figure 2: Calculation of torque & slot dimension

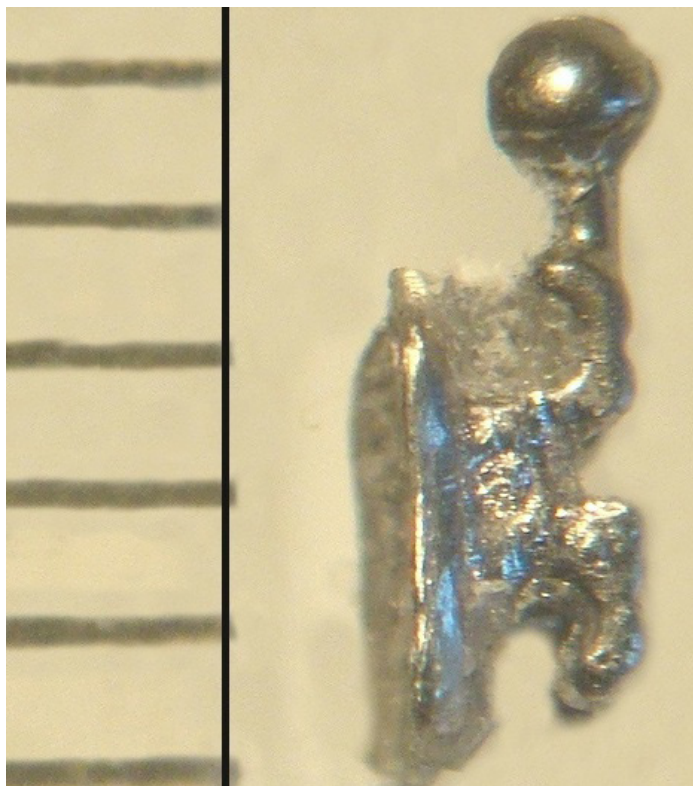


Figure 3: Slot Distortion