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Original Research Article

A Comparison of the slot dimensions, in-built tip and torque of MBT prescription bracket systems of 5 commercially available orthodontic metal brackets manufactured by Indian companies: A stereo-microscopic study

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Abstract

Background: Complete expression of the In-built tip and torque is important to achieve the desired final positioning of teeth and a stable and aesthetic result. For this, slot height, torque and tip incorporation within the bracket must be accurate. Although bracket prescriptions are expected to be precise, several studies have indicated differences between the given and true prescriptions of orthodontic brackets. Discrepancy in the mentioned and true values may result in losing control over biomechanics, leading to inadequate treatment finishing and compromised results. The study aims to examine the accuracy provided in orthodontic bracket specifications, especially slot dimensions, tip and torque values of five commercially available Indian orthodontic bracket systems using a stereomicroscope.

Materials and Methods: 10 upper central incisor brackets of MBT prescription (0.022-inch slot) were selected from 5 different bracket series manufactured by Indian companies. Each bracket was mounted on an acrylic block made of cold-cure acrylic resin. It was viewed under a Stereomicroscope to assess the accuracy of the mentioned slot height, in-built tip and the torque of the bracket. Images obtained were digitally measured and values were obtained.

Results: The study identified areas for enhancement in tip, torque, and slot height measurements across the bracket series evaluated, with the Sapphire brackets notably accurate in size. Mean tip values increased overall, though not significantly. Most series showed reduced mean torque values, except the Micro LP Brackets, which saw an increase. These findings suggest opportunities for refining bracket design and manufacturing to improve precision and performance.

Conclusion: The above study makes it important for orthodontists to be careful when choosing brackets for fixed appliance therapy in clinical practice, to achieve ideal results and avoid the need for additional wire bending. Clinicians must acknowledge the imperfections in the manufactured brackets and take proactive control over the appliance and dictate the outcome

Keywords: MBT, Slot dimensions, Torque, Tip, Stereomicroscope, Indian companies

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1. Introductions

Orthodontic treatment aims at achieving the triad of objectives given by Jackson i.e Functional Efficiency, Structural Balance and Esthetic Harmony. This requires accurate positioning and inclination of all teeth at the end of treatment and can be achieved by using various appliances, techniques, and modalities available in orthodontics. With innovation in materials science and technology, there are endless possibilities for treatment plans. However, a drawback that persists is the heightened variability, which necessitates clinicians to exert control over a larger array of factors. The MBT ™ bracket system was developed by Dr Richard McLaughlin, Dr John Bennett and Dr Hugo Trevisi in 1997. It is a third-generation Pre-adjusted edgewise appliance that incorporated a range of prescription changes to overcome the clinical inadequacies of earlier Pre-adjusted edgewise bracket systems.[1] This led to variations in the tip and torque accepted worldwide today. A satisfactory incisor

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torque is important for the final aesthetic finish.[2] Control of the maxillary incisor torque is important for an ideal inter-incisal angle, adequate incisor contact, and anterior-posterior positioning of the dentition to achieve an ideal occlusion.[3] Ideally, placement of the correct arch-wire in the perfect bracket slot should have resulted in the correct and mentioned tip and torque expression. The entire purpose of the appliance was for it to happen without needing additional wire bindings.

Yet in recent studies inaccuracies have been noticed in the end of treatment majorly is in the torque expressed. In a clinical setting, there was a need for further wire bending to achieve the ideal inclination and final position of the teeth. Essentially it was noted to be the loss of bucco-palatal inclination of the incisors during the space closure and finishing stages. Despite the longstanding assumption of precision in bracket slot measurements, various studies have revealed discrepancies between the stated sizes of orthodontic brackets and their true dimensions.

2. Materials and Methods

The study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics and in the Department of Oral Pathology, D.Y. Patil University, School of Dentistry, Navi Mumbai

This study was carried out on 10 brackets of 0.022"x 0.028" MBT prescription selected as per the inclusion and exclusion criteria from various bracket series manufactured in India (50 in total). Each company and bracket series were assigned a respective colour as follows:

JJ orthodontics: Orthox Bracket Series: Group 1: Purple
JJ orthodontics: XB TM Direct Bond Bracket Series: Group 2: Red.

Modern Orthodontics: Micro LP Series: Group 3: Yellow
Modern Orthodontics: Sapphire Series: Group 4: Green
Welcare Orthodontics: Precize Brackets Series: Group 5: Pink. (**Figure 1** and **Figure 2**)

Each bracket was mounted on an acrylic block made of cold-cure resin and modelling wax. This assembly was referred to as a "WEDGE.

The wax allowed for maneuvering of the bracket in the lateral view to capture the bracket slot at a perpendicular angle. The "wedges" were then viewed under a stereomicroscope in the frontal and lateral view and images with the measurements were obtained.

2.1: Inclusion criteria

1. 0.022 MBT Prescription Brackets
2. Brackets made of stainless steel
3. Upper Left Central Incisor Brackets
4. Indian Manufacturing Companies

2.2: Exclusion criteria

1. 018 slot prescription brackets
2. Ceramic brackets
3. Self-ligating brackets

2.3: Measurement methodology

The ideal values decided for the brackets were as follows: slot height of 0.022 inches, tip value of 4° and torque value of 17°.

1. ***Tip measurement:*** The frontal view of the brackets was observed under the Stereomicroscope in 100x magnification. The bracket tip was measured as the angle between the long axis of the bracket and a line joining the lower border of the upper wings.(**Figure 3** and **Figure 4**)
2. ***Torque measurement:*** The side view of the brackets was observed under the Stereomicroscope in 100x magnification. It was measured as the angle between the long axis of the bracket base & long axis of the slot base. Reference points were marked and lines were drawn. Two points were marked at the bracket base and two on the slot base at the junction of the angle between the wing's internal wall and the slot floor. Two lines connecting the points of the bracket base and slot base were drawn and extended until they met.(**Figure 5** and **Figure 6**)
3. ***Slot height measurement:*** The side view of the brackets was observed and images were captured under the stereomicroscope in 400x magnification. The slot height was calculated by measuring the linear distance of the line drawn parallel to the slot base.(**Figure 7** and **Figure 8**)

2.4: Statistical analysis

Descriptive statistics were expressed as means and standard deviation. The comparison of the slot dimensions, in-built torque and tip between five commercially available bracket systems was analyzed using One Way ANOVA test followed by post hoc Bonferroni test for pairwise comparison. P value less than or equal to 0.05 was considered statistically significant. All analyses were performed using the SPSS version 25.

3. Results

3.1. Analysis of tip

The tip value obtained was compared to the prescribed value of 4°. The mean tip values observed were as follows: Group 1 (4.4391°), Group 2 (4.8026°), Group 3 (4.7560°), Group 4 (4.5229°) and Group 5 (4.5136°). The incorporated tip of brackets in Group 1: The Orthox bracket was closest to the prescribed value with a deviation of 10.98%. While the incorporated value of brackets in group 2: XBTM Direct Bond Bracket Series were farthest away from the

prescribed value with deviations of 20.07%. The incorporated tip values were greater in all 5 bracket groups. Comparison among the study groups indicates no statistically significant difference in the mean incorporated tip values.

Figure 1: Various colour blocks corresponding to the respective bracket series and wedge assemblies prepared

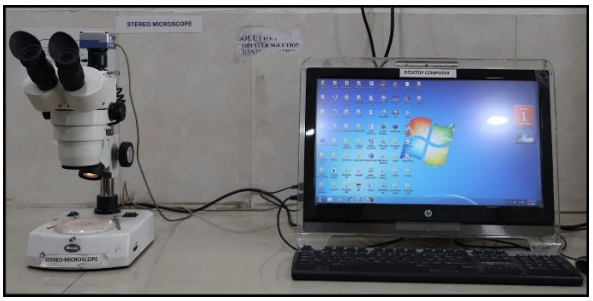

Figure 2: Stereomicroscope with connected computer

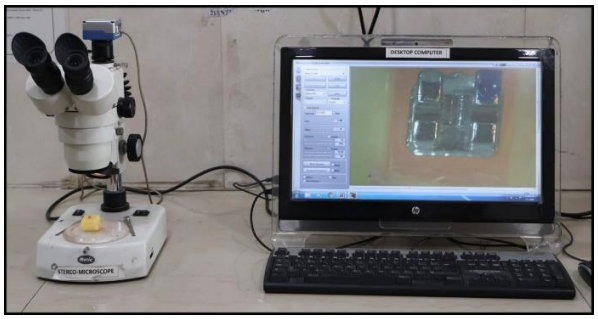

Figure 3: Obtaining Frontal view image of Wedge at 100x magnification

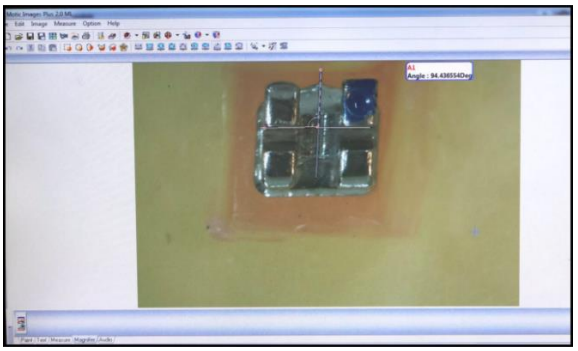

Figure 4: Measurement of in built tip

Figure 5: Obtaining lateral view image of Wedge at 100x magnification

Figure 6: Measurement of in built torque

Figure 7: Obtaining lateral view image of Wedge at 400x magnification

Figure 8: Measurement of in built Slot height

Table 1: Descriptive statistics for tip angles of brackets

Types of brackets	N	Minimum	Maximum	Mean	Standard deviation	% deviation from ideal tip (4°)
Orthox Bracket Series	10	4.1071	4.8842	4.4391	0.2602	10.98%
XB ™ Direct Bond Bracket Series	10	4.2326	5.9751	4.8026	0.5765	20.07%
Micro LP Series	10	4.3324	5.4316	4.7560	0.3150	18.9%
Sapphire Series	10	4.1719	4.8691	4.5229	0.2567	13.07%
Precize Bracket Series	10	4.1457	5.7556	4.5136	0.4500	12.84%

Table 2: Comparison of tip angle values of MBT Prescription Bracket of 5 commercially available Orthodontic Metal Brackets.

Type of bracket	Mean	Standard deviation	P value (One Way ANOVA test)
Orthox Bracket Series	4.4391	0.2602	0.167
XBTM Direct Bond Bracket Series	4.8026	0.5765	
Micro LP Series	4.7560	0.3150	
Sapphire Series	4.5229	0.2567	
Precize Bracket Series	4.5136	0.4500	

*p≤ 0.05 is statistically significant

Table 3: Pairwise comparison of tip angle values of mbt prescription bracket of 5 commercially available orthodontic metal brackets.

(I)group	(J) group	Mean Difference (I-J)	Std. Error	Sig.(Post hoc Bonferroni test)	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-.3634600	.1752540	.438	-.880824	.153904
	3	-.3168300	.1752540	.773	-.834194	.200534
	4	-.0837400	.1752540	1.000	-.601104	.433624
	5	-.0744300	.1752540	1.000	-.591794	.442934
2	3	.0466300	.1752540	1.000	-.470734	.563994
	4	.2797200	.1752540	1.000	-.237644	.797084
	5	.2890300	.1752540	1.000	-.228334	.806394
3	4	.2330900	.1752540	1.000	-.284274	.750454
	5	.2424000	.1752540	1.000	-.274964	.759764
4	5	.0093100	.1752540	1.000	-.508054	.526674

*p≤ 0.05 is statistically significant

Table 4: Descriptive statistics for torque angles of brackets

Types of brackets	N	Minimum	Maximum	Mean	Standard deviation	% deviation from ideal torque (17°)
Orthox Bracket Series	10	8.5500	11.1690	9.8470	0.8736	-42.08%
XB™ Direct Bond Bracket Series	10	12.4660	15.7600	13.8362	1.0031	-18.61%
Micro LP Series	10	17.0720	17.9450	17.5010	0.2992	2.95%
Sapphire Series	10	7.2200	9.9780	8.8430	0.8112	-47.98%
Precize Bracket Series	10	9.7910	14.5970	11.8260	1.61885	-30.44%

Table 5: Comparison of torque angle values of MBT Prescription Bracket of 5 commercially available Orthodontic Metal Brackets.

Type of bracket	Mean	Standard deviation	P value (One Way ANOVA test)
Orthox Bracket Series	9.8470	0.8736	**<0.001***
XB^{TM} Direct Bond Bracket Series	13.8362	1.0031	
Micro LP Series	17.5010	0.2992	
Sapphire Series	8.8430	0.8112	
Precize Bracket Series	11.8260	1.61885	

*p≤ 0.05 is statistically significant

Table 6: Pairwise comparison of torque angle values of MBT Prescription Bracket of 5 commercially available Orthodontic Metal Brackets.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig. (Post hoc Bonferroni test)	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-3.98920000*	.45332132	.000*	-5.3274404	-2.6509596
	3	-7.65400000*	.45332132	.000*	-8.9922404	-6.3157596
	4	1.00400000	.45332132	.319	-.3342404	2.3422404
	5	-1.97900000*	.45332132	.001*	-3.3172404	-.6407596
2	3	-3.66480000*	.45332132	.000*	-5.0030404	-2.3265596
	4	4.99320000*	.45332132	.000*	3.6549596	6.3314404
	5	2.01020000*	.45332132	.001*	.6719596	3.3484404
3	4	8.65800000*	.45332132	.000*	7.3197596	9.9962404
	5	5.67500000*	.45332132	.000*	4.3367596	7.0132404
4	5	-2.98300000*	.45332132	.000*	-4.3212404	-1.6447596

*p≤ 0.05 is statistically significant

Table 7: Descriptive statistics for slot height of brackets

Types of brackets	N	Minimum	Maximum	Mean	Standard deviation	% deviation from ideal slot height (0.022")
Orthox Bracket Series	10	.0220	0.0241	0.0228	0.0006	3.64%
XB^{TM} Direct Bond Bracket Series	10	.0233	0.0248	0.0242	0.0004	10%
Micro LP Series	10	.0212	0.0228	0.0222	0.0005	0.9%
Sapphire Series	10	.0202	0.0223	0.0216	0.0008	-1.82%
Precize Bracket Series	10	.0221	0.0250	0.0230	0.0008	4.55%

Table 8: Comparison of slot height of MBT prescription bracket of 5 commercially available

Type of bracket	Mean	Standard deviation	P value (One Way ANOVA test)
Orthox Bracket Series	0.0228	0.0006	<0.001*
XB^{TM} Direct Bond Bracket Series	0.0242	0.0004	
Micro LP Series	0.0222	0.0005	
Sapphire Series	0.0216	0.0008	
Precize Bracket Series	0.0230	0.0008	

*p≤ 0.05 is statistically significant

Table 9: Pairwise comparison of slot height of MBT Prescription Bracket of 5 commercially available orthodontic metal brackets.

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig. (Post hoc Bonferroni test)	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-.00135310*	.00028709	.000*	-.0022006	-.0005056
	3	.00059230	.00028709	.449	-.0002552	.0014398
	4	.00120430*	.00028709	.001*	.0003568	.0020518
	5	-.00015430	.00028709	1.000	-.0010018	.0006932
2	3	.00194540*	.00028709	.000*	.0010979	.0027929
	4	.00255740*	.00028709	.000*	.0017099	.0034049
	5	.00119880*	.00028709	.001*	.0003513	.0020463
3	4	.00061200	.00028709	.385	-.0002355	.0014595
	5	-.00074660	.00028709	.125	-.0015941	.0001009
4	5	-.00135860*	.00028709	.000*	-.0022061	-.0005111

*p≤ 0.05 is statistically significant

3.2. Analysis of torque

The torque value obtained was then compared to the prescribed value of 17°. The incorporated torque of brackets in Group 3: Micro LP Series was closest to the prescribed value with a deviation of 2.95% while the incorporated value of brackets in group 4: Sapphire Series were farthest away from the prescribed value with a deviation of -47.98%. The incorporated torque values were less in all bracket groups except group number 3 where it was increased. Comparison among the group indicates a statistically significant difference in the incorporated torque values.

3.3. Analysis of slot height

The slot height obtained was compared to the prescribed value of 0.022 inches. The slot height of brackets in Group 3: The Micro LP Series had a deviation of just 0.9% from the specified value, making it the closest match, while the slot height of brackets in Group 2: XB^{TM} Direct Bond Bracket Series was farthest away from the prescribed value with a deviation of 10%. it was observed that all groups except group 4: Sapphire Series had oversized brackets, while group 4 brackets were undersized.

4. Discussions

Orthodontic treatment and its success rely on a variety of factors. Achievement of stable long-term results, requires accurate diagnosis, the right treatment plan and proper execution of it. The tools and mediums required for the same should work in conjunction with the orthodontist's skill and knowledge to achieve the same with minimal hindrance and discomfort in the patient experience. Even the most minor differences in the bracket prescription can result in issues during the finishing phase. This study aimed to evaluate the in-built tip and torque values and the slot height as mentioned by the manufacturers.

What was observed in this study was that the bracket series tip values were different from what was prescribed by the manufacturers. The deviation was insignificant with Group 1: Orthox bracket being closest to the value, and Group 2: XBTM Direct Bond Bracket Series being farthest away from the mentioned value of 4°. The possible cause and reason could be errors during the manufacturing process. Any deformation in the lower border of the upper wings and the long axis of the bracket could result in an inappropriate tip.

Meiling et al.[4] found that applying a second-order couple via a bracket to a twisted arch wire results in the creation of a small third-order couple. This newly generated couple has a restricting effect on the interaction between the arch wire and the bracket.

Awasthi et al[5] evaluated a set of 0.022-inch metal brackets with MBT prescriptions from six manufacturers. Their findings revealed that the mean tip values varied between 1.67° and 6°, with the actual mean values significantly differing from those stated in all the assessed bracket series.

The torque values of the brackets should follow the nominal values given by the manufacturers.[6] Brackets selected for this study did not have correct torque angulations with most of the brackets being under-torqued. Only Group 3: Micro LP had torque values closer to the prescribed values. The purpose of the pre-adjusted edgewise system was to ensure there was no further need for wire bending to achieve the desired finish. The MBT system already shows poor torque expression owing to a small area of application of

torque. Having under-torqued brackets reduces the efficacy of the prescribed system and mechanics.

Alessandra Motta Streva[7] in her study also noted that the average torque values for the brackets were within the prescribed values of the MBT technique, except for the maxillary canine brackets of the Morelli brand. The mandibular canine brackets of American Orthodontics and Ortho organizers presented significant differences. There were substantial differences in the torque values of some of the brackets assessed, which would clinically affect the anterior-posterior positioning of teeth at the end of treatment.

Similar findings were also seen in studies conducted by Ashish Mathew.[8] The average values for torque were reduced in all the brackets. The brackets from JJ Orthodontics and Desires presented major differences from the ideal torque values. The cause of the disparity in torque values of the orthodontic brackets maybe due to manufacturing errors in aligning the slot base and bracket base. If the mold for the slot base is not acuurately aligned during the manufacturing process of injection molding, casting, or milling, the die for the slot base will be incorrect, causing a change in the angle between the base and face, ultimately varying the torque of the bracket.

The slots of the brackets measured were evaluated and it was noted that most of the slot heights were oversized. What was also noted was the curved corners of the bracket slot in most of the brackets and inaccuracies in the walls of the bracket slot. Brackets showed defects breaks along the upper and lower walls of the bracket.

Our findings were in accordance with the study done by Cash and colleagues who observed that the bracket slots were generally larger than specified. They noted that only twin torque, clarity, and mini-mono brackets were found to be within their stated dimensions, falling within a range of ± 5%.[9]

Kusy and Whitley[10-11] in their study on 24 brackets by various manufacturers found that three brackets had slot dimensions smaller than the “prescription value” and the remaining had slot dimensions larger than the “prescription value.”

Siatkowski[12] observed that anterior teeth suffered torque loss when oversized brackets were used and it might not result in desirable tooth movement. He stated the difference in the manufacturing measurement system between American and European orthodontic bracket manufacturers.

The potential cause of this variation may arise from the diverse manufacturing processes such as injection molding, casting, or milling, which can impact the precision of prescribed torque values. During molding, the material is subjected to expansion and shrinkage, while milling can result in a rough-grained surface. Casting may lead to shrinkage defects when there is not enough standard feed metal available to counteract shrinkage as the thick metal solidifies.

Taking all aspects into account, pre-adjusted systems have offered substantial advantages to orthodontists throughout the treatment process, with the MBT™ appliance system representing a notable advancement over previous systems. The considerable variation observed in all measurements in our research underscores the importance of considering individual differences when treating patients. It is evident that a single pre-adjusted appliance prescription cannot universally accommodate all patients.

5. Conclusion

This study provided analysis on the in-built prescription in terms of tip torque and slot height, in various commercially available 0.022-inch MBT brackets manufactured in India. The findings of the study were as follows:

1. This study demonstrated that the mean slot height of brackets from Orthox series, XB™ Direct Bond Bracket Series, Micro LP Series and Precize SB Bracket Series were significantly increased and brackets were oversized. While the mean slot height of Sapphire Series brackets was reduced and brackets were undersized. The Micro LP Series show the least deviation from the ideal value.
2. The mean torque values of brackets of Orthox series, XB™ Direct Bond Bracket Series, Sapphire Series and Precize Bracket Series were significantly reduced while mean torque values were increased in Micro LP Series.
3. The mean tip values of all bracket groups were increased, but it was not statistically significantly deviated.

5.1. Consent for publication

All the authors provide their consent for their publication.

6. Author Contributions

Author 1 helped with the conception, project design and overall *project administration*. Author 2 contributed to resource acquisition. Author 3 helped with the operating of the software. Author 4 helped with the conception, formal analysis, primary investigation data acquisition and drafting the manuscript. Author 5 served as the primary supervisor of the project.

7. Source of Funding

Self-Funded.

8. Conflict of Interest

None.

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