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Original Research Article

Assessment of inclination and angulation of maxillary anterior teeth using different commercially available MBT bracket systems - A CBCT study

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Abstract

Background: The invention of the preadjusted appliance allowed for simpler mechanics and less wire bending. The expression of the inbuilt tip and torque incorporated into its slot or base is possible after full engagement of rectangular wire. This have its implication on inclination and angulation of the teeth

Aim and objectives: The study aimed to assess the inclination and angulation of maxillary anterior teeth using different commercially available MBT bracket system using CBCT scans.

Materials and Methods: Thirty-three subjects were divided into two groups. Group 1 bonded with Gemini™ (3M Unitek) MBT Bracket System and Group 2 bonded with Mini Diamond™ (Ormco) MBT Bracket System. Two CBCT scan was taken after 6-8 weeks of placement of 0.019"x0.025" SS archwire (T_0) and 0.021" x 0.025" SS archwire (T_1) of same patient. Each evaluated data was entered into excel sheet and analysed using Shapiro Wilk test.

Result: The mean change in inclination and angulation in either group was found to be statistically insignificant at T_0 and T_1 whereas the mean change from T_0 to T_1 between the 2 groups were found to be statistically significant in all six maxillary anterior teeth.

Conclusion: The result showed no significant difference observed in inclination & angulation of maxillary anterior teeth in both groups at T_0 and T_1. Whereas the mean change from T_0 to T_1 was maximum and statistically significant in Group I compared to Group II.

Keywords: Inclination, Angulation, 3M Unitek, Ormco, Stainless steel archwire, CBCT

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1. Introduction

The Edgewise appliance, created by Angle, marked a significant advancement in orthodontics.[1] Before the 1970s, when Andrews introduced the straight wire bracket system, orthodontists had to manually adjust archwires to position teeth correctly. The innovation of pre-adjusted brackets, which include built-in information like torque and tip, transformed this process by reducing the need for manual wire adjustments.[2-3]

Torque, an essential component for controlling the axial inclination of teeth, can be either positive or negative. Positive torque refers to a situation where the root is positioned lingually relative to the crown, while negative torque occurs when the root is positioned facially. In orthodontics, torque is the force applied to a rectangular archwire within the bracket slot.[4]

Initially, torque was adjusted by modifying the bracket base, a method known as "torque in base." Later, this adjustment was refined by altering the bracket face, referred to as "torque in face."[3]

Proper expression of bracket tip is crucial for delivering the desired torque, which in turn ensures correct tooth inclination and angulation.[2] To achieve Andrews' six keys of normal occlusion, it's essential to use an archwire that matches the bracket's torque and tip specifications.[5]

In orthodontics, applying the right amount of force is vital. Lower forces are more effective, while excessive forces

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can impede tooth movement by reducing periodontal tissue cellular activity.[6] Any gap or play between the bracket and wire can lead to incomplete transmission of the bracket's intended adjustments to the tooth and its surrounding tissues.[3]

For evaluating maxillary anterior teeth position, a number of approaches have been used. These includes cephalometric measures, intraoral or cast tooth inclination protractor, 3D cast models.[7] A study by Magkavali-Trikka et al. (2019) constructed a virtual model of root with software to estimate the root inclination. But this method requires precise silicone impressions, varnishes for coating the teeth, and three separate superimpositions. Conventionally, panoramic radiographs have been used for measuring teeth angulation but they have limits when used for measuring inclination as they had distortions do not replicate true 3D angulations. Whereas lateral cephalogram can only be used to assess inclination.[7]

CBCT provides high-resolution, distortion-free 3D images, allowing for accurate measurement and visualization of both the crown and root of each tooth, thus enhancing diagnostic precision and treatment planning.[7] Ludlow et al (2007), Lascala et al (2004), Kobayashu et al (2004) also proved that the CBCT images provide more precise linear measurements and volumes.

So, the aim of the present study, was to assess the inclination and angulation of maxillary anterior teeth over CBCT using different commercially available MBT bracket systems.

2. Materials and Methods

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics. A total of thirty-three subjects were chosen for the present study who required orthodontic treatment (**Figure 1**) for sample calculation. Out of which twenty-four subjects were regular for the follow up and nine subjects discontinued the treatment in between due to bracket breakages, not turning up for the follow up and migration.

The inclusion criteria were: (a) Subjects who had to undergo fixed orthodontic treatment using MBT prescription. (b) Subjects with bimaxillary protrusion. (c) Subjects with full complement of permanent teeth. Exclusion criteria were: (a) Subjects with skeletal or dental malformations. (b) Subjects having any missing teeth in maxillary arch. (c) Subjects with anterior tooth morphology problems like Peg laterals.

All the subjects were informed about the purpose of the study and a signed informed consent was received from each subject. (**Figure 1**)

Subjects chosen for this prospective study were divided into two groups based on the MBT bracket system used.

1. Group 1: Subjects bonded with Gemini™ (3M Unitek) MBT Bracket System; 0.022" x 0.028" slot (n=12)
2. Group 2: Subjects bonded with Mini Diamond™ (Ormco) MBT Bracket System; 0.022" x 0.028" slot (n=12)

Leveling and aligning was completed in either group and the maxillary arch received 0.019"x0.025" SS archwire. After placement for 6-8 weeks, CBCT scans for six maxillary anterior teeth were taken (T0). Subjects were then ligated with 0.021"x0.025" SS archwire for a period of 6-8 weeks. CBCT scans for six maxillary anterior teeth were repeated (T_1).

The images were analysed using the i-CAT Vision Software, a Cone Beam Computed Tomography Device (Imaging Sciences International, Hatfield, PA, USA) employing the multi-planar reconstruction (MPR) window. Field of View- 8 X 8 with 0.1 mm of slice thickness and 0.25 voxels. The acquisition time for each slice was 14.5 seconds and the reconstruction time was 60 sec.

Reference plane for evaluating the inclination was the occlusal plane which is an imaginary line extending from the cusp tip of molars, premolars to the incisal edges. Vertical line drawn perpendicular to occlusal plane and long axis of the tooth. Apex and incisal cusp were taken as reference point for long axis in relation to the maxillary occlusal plane. The long axis of maxillary anterior teeth for left and right sides were drawn on their respective CBCT scans. From the frontal view, angle between the long axis of maxillary anterior teeth and the line perpendicular to occlusal plane gives the angulation (**Figure 2**). From the lateral view, angle between line long axis of maxillary anterior teeth and the line perpendicular to the occlusal plane evaluates the inclination. (**Figure 3**). These were measured at T_0 and T_1.

This measured data were analyzed using Statistical Package of Social Sciences Sciences (SPSS) version 21 using Shapiro Wilk test. On achieving normal data, parametric tests of significance (One-way ANOVA) were used for inferential statistics. The level of statistical significance was set at 0.05.

3. Results

Table 1 shows maximum mean change in angulation at T_0 and T_1 (MBT bracket system receiving 0.019" x 0.025" SS wire and MBT bracket system receiving 0.021" x 0.025" SS wire respectively) in subjects bonded with 3M Unitek MBT bracket system / Group 1 when compared to subjects bonded with Ormco MBT bracket system / Group 2. **Table 2** shows maximum mean change in inclination at T_0 and T_1 in Group 1 when compared to Group 2

However, the mean change in angulation and inclination in either group was found to be statistically insignificant for the six maxillary anterior teeth.

Table 3 shows the mean change in angulation and inclination from T_0 to T_1 was found to be maximum in Group 1 when compared to Group 2. The mean change in angulation and inclination from T_0 to T_1 between 3M Unitek and Ormco MBT was found to be statistically significant in all six maxillary anterior teeth ($p < 0.001$).

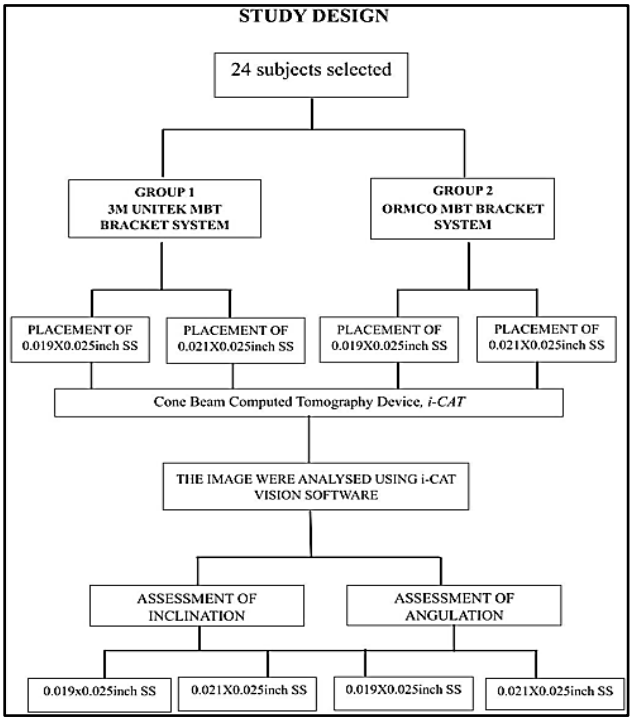


Figure 1: Study Design

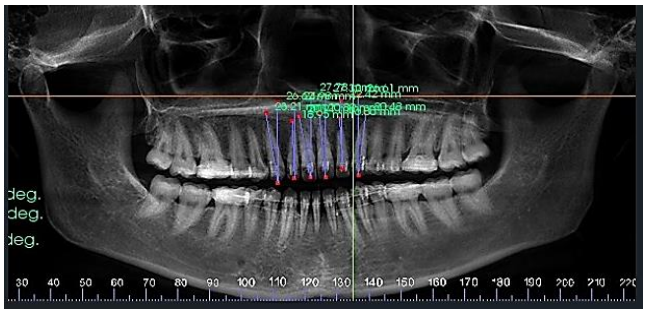
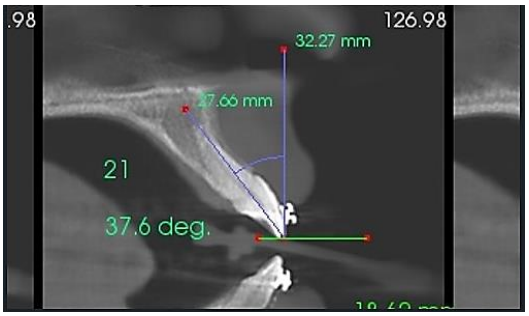


Figure 2:



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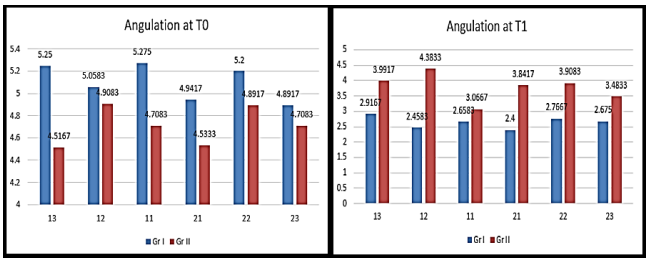
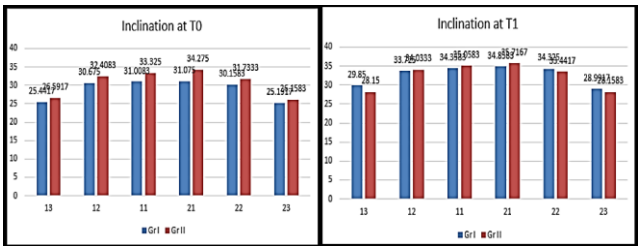
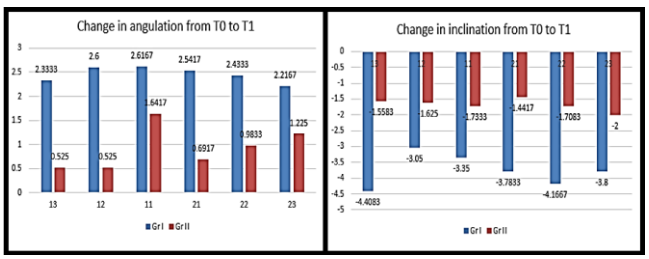


Graph 1: Intergroup comparison of mean angulation at T_0 and T_1



Graph 2: Intergroup comparison of mean inclination at T_0 and T_1



Graph 3: Intergroup comparison of absolute change in mean angulation and inclination at T_0 and T_1

Table 1: Intergroup comparison of mean angulation at T0 and T1

			Angulation at T_0 (MBT bracket system receiving 0.019"X 0.025" SS wire)			Angulation at T_1 (MBT bracket system receiving 0.021" X 0.025" SS wire)		
Tooth	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Mean**	**Std. Deviation**	**P value**
13	Gr I	12	5.2500	1.84563	0.407, NS	2.9167	1.60274	0.208, NS
	Gr II	12	4.5167	2.37251		3.9917	2.37849	
12	Gr I	12	5.0583	1.49816	0.846, NS	2.4583	.90298	0.10, NS
	Gr II	12	4.9083	2.17484		4.3833	2.19165	
11	Gr I	12	5.2750	1.63658	0.505, NS	2.6583	1.26164	0.554, NS
	Gr II	12	4.7083	2.38878		3.0667	1.99013	
21	Gr I	12	4.9417	1.38725	0.551, NS	2.4000	1.18935	0.460, NS

	Gr II	12	4.5333	1.88117		3.8417	2.04159	
22	Gr I	12	5.2000	1.68900	0.738, NS	2.7667	1.34457	0.150, NS
	Gr II	12	4.8917	2.66815		3.9083	2.28690	
23	Gr I	12	4.8917	1.86911	0.842, NS	2.6750	1.69552	0.261, NS
	Gr II	12	4.7083	2.53035		3.4833	1.73301	

Table 2: Intergroup comparison of mean inclination at T_0 and T_1

			Inclination at T_0 (MBT bracket system receiving 0.019"X 0.025" SS wire)			**Inclination at T_1 (MBT bracket system receiving 0.021"X 0.025" SS wire)**		
Tooth	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Mean**	**Std. Deviation**	**P value**
13	Gr I	12	25.4417	2.41490	0.483, NS	29.8500	2.65724	0.306, NS
	Gr II	12	26.5917	5.03559		28.1500	4.95002	
12	Gr I	12	30.6750	5.33157	0.459, NS	33.7250	5.34775	0.893, NS
	Gr II	12	32.4083	5.92904		34.0333	5.67952	
11	Gr I	12	31.0083	5.22032	0.362, NS	34.3583	5.01225	0.782, NS
	Gr II	12	33.3250	6.86230		35.0583	7.06289	
21	Gr I	12	31.0750	5.81145	0.215, NS	34.8583	5.44785	0.731, NS
	Gr II	12	34.2750	6.45701		35.7167	6.56517	
22	Gr I	12	30.1583	4.30548	0.507, NS	34.3250	4.21882	0.708, NS
	Gr II	12	31.7333	6.85159		33.4417	6.87743	
23	Gr I	12	25.1917	3.43126	0.577, NS	28.9917	3.95577	0.644, NS
	Gr II	12	26.1583	4.81635		28.1583	4.71197	

Table 3: Intergroup comparison of absolute change in mean angulation and inclination from T_0 to T_1

			Change in angulation from T_0 to T_1			**Change in inclination from T_0 to T_1**		
Tooth	**Group**	**N**	**Mean**	**Std. Deviation**	**P value**	**Mean**	**Std. Deviation**	**P value**
13	Gr I	12	2.3333	.75358	<0.001, S	-4.4083	1.57622	<0.001, S
	Gr II	12	.5250	.72754		-1.5583	.57912	
12	Gr I	12	2.6000	.92146	<0.001, S	-3.0500	.88780	<0.001, S
	Gr II	12	.5250	1.26500		-1.6250	.65105	
11	Gr I	12	2.6167	.80773	0.013, S	-3.3500	3.10205	<0.007, S
	Gr II	12	1.6417	.95865		-1.7333	.85209	
21	Gr I	12	2.5417	.88468	<0.001, S	-3.7833	1.28263	<0.001, S
	Gr II	12	.6917	.39877		-1.4417	.61416	
22	Gr I	12	2.4333	.83485	<0.001, S	-4.1667	1.82724	<0.001, S
	Gr II	12	.9833	.73216		-1.7083	.54349	
23	Gr I	12	2.2167	.61914	0.007, S	-3.8000	1.36848	<0.001, S
	Gr II	12	1.2250	.97153		-2.0000	.43064	

4. Discussion

Dimensional inaccuracies in brackets can arise from various manufacturing processes. Streva et al.[8] highlighted that such inaccuracies might be linked to insufficient compression during casting and injection moulding, which can cause internal gaseous porosity in the metal. This porosity weakens the metal's microstructure, increasing its susceptibility to deformation. Furthermore, the milling process can introduce surface roughness and imperfections to the brackets, leading to a high-friction bracket-wire interface. As a result, these factors can cause stress accumulation and deformation of the bracket slot, contributing to the observed variations in angulation changes between the two bracket systems.[9] Meiling et al.[10] reported that slight angulation of the bracket wings relative to its long axis can influence the bracket's internal tip. Consequently, any discrepancies in wing orientation could affect the bracket's tip. Doddamani et al. [11] and Loenen et al.[12] which reported greater levels of inclination in maxillary incisors compared to the findings of Currim and Wadkar, as well as Vardimon and Lambertz. Notably, there were significant differences in the size, shape, and form of canines and incisors.[13-14] According to Bryant et al.[15] caution is advised when torquing a tooth with a significant crown-root angle. Kapur et al.[16] stated that the lack of significance may be attributed to differences in slot design, the degree of play between the bracket and wire, ligation, inter-bracket distance.

Several studies have identified additional factors influencing tip and torque expression in orthodontics, including crown morphology, the anatomy of the facial aspect of teeth, tooth size, and variations in direct bonding

techniques. Anjos et al. (2015) emphasized that bracket prescription and positioning significantly impact the displacement of the root apex and crown tip.[17] Furthermore, research by Loenen et al. (2005), Vigorito et al. (2006), and Mestriner et al. (2006) demonstrated that variations in the height at which brackets are placed on the tooth surface lead to considerable differences in torque expression. These findings underscore the complexity of factors affecting orthodontic treatment outcomes.[16]

Cash et al.[18] Stated the significant difference in mean angulation and inclination was due to the disparity attributed in differences in bracket dimensions between the MBT bracket systems. Specifically, the 0.022" slot size of the 3M Unitek brackets approximates the standard slot size of 0.0219 inches, whereas the 0.022" slot size of the Ormco brackets is slightly smaller than the standard at 0.0210 inches. Furthermore, the research by Alavi et al.[5] indicated that brackets from different manufacturers exhibit varying degrees of play and torque functions.

Orthodontic clinicians should be aware that preadjusted bracket and wire systems might not always provide the precise 3D control needed, particularly for correcting incisor inclination. Inaccurate manufacturing dimensions can necessitate additional root torque for upper incisors, complicating the use of these systems. This may prompt clinicians to consider zero-base edgewise treatments or preprogrammed brackets with increased incisor torque. However, consistent results depend on a close fit between slots and wires.

5. Conclusion

The study found that the mean change in inclination and angulation of six maxillary anterior teeth was greater and significant with 3M Unitek compared to Mini-Diamond Ormco. Future research with larger sample sizes is needed. Clinicians should be aware that orthodontic brackets with oversized slots may lead to three-dimensional shifts in tooth positioning.

6. Source of Funding

None.

7. Conflict of Interest

None.

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