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RESEARCH ARTICLE

EVALUATION AND COMPARISION OF BRACKET SLOT DIMENSIONS OF COMMERCIALLY AVAILABLE PRE ADJUSTED EDGEWISE APPLIANCE – AN IN -VITRO STUDY

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ABSTRACT

As to achieve a desired tooth movement the bracket slot dimensions need to be accurate, if not the treatment would be compromised. Slot dimensions are a critical factor in orthodontic tooth movement. However very little is known about the accuracy of the slot dimensions of commercially available brackets.

Aims and objectives: To evaluate slot dimensions of four different commercially available 0.022 slot MBT prescription brackets.

Materials and Methods: 100 Upper right central incisor brackets from 4 different manufacturers(3M Unitek -Gemini 0.022, American orthodontics-Mini Masters 0.022, Chirpans orthodontics – Eco-plus 0.022, Modern orthodontics-Sapphire 0.022) were measured for slot depth and width using confocal microscope which gives a digital readout accurate upto 1 micron and the brackets were grossly examined for surface defects using microscopic images.

Results: The slot sizes were oversized, or undersized ranging from 0.017 inches to 0.031 inches, none of the manufacturers brackets were dimensionally accurate, surface irregularities were more evident in sapphire and Eco-Plus bracket slots

Conclusion: Slot dimensions are not accurate, which might directly and unintentionally affect the planned tooth movement.

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INTRODUCTION

Slot dimensions are a critical factor in orthodontic tooth movement, as to achieve a desired tooth movement the bracket dimensions need to be accurate, if not the treatment would be compromised and clinician will have to compensate by applying bends in the wire, This clearly reduces the simplicity and effectiveness of a preadjusted system. It is necessary to know whether the slot dimensions of these brackets are accurate. In the orthodontic specialty, the placing of maximum prescription archwires in a preadjusted bracket is designed to produce three-dimensional tooth-moving forces. 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.

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For example, when retracting a maxillary incisor to reduce an overjet, slop between the bracket and wire results in palatal tipping of the crown, with the root of the tooth concurrently moving labially (Cash *et al*., 2004). Oversized or undersized brackets leads to loss of torque, compromise sliding adversely affect three dimensional positioning, for every 0.001 inch of freedom between arch wire and slot there is approximately 5 degrees of torque loss, for every 5 degrees of torque loss average maxillary incisor tips by 1.3 mm and mandibular incisor tips by 1.22 mm (Kusy *et al*., 1999). However very little is known about the accuracy of the slot dimensions of commercially available brackets. In the recent times there has been an increase in the use of commercially available economic brackets There is increase in trend to use these brackets due to ease of availability and low cost. The purpose of this study is to evaluate slot dimensions of commercially available brackets from the different manufacturers as well as difference in slot dimensions in brackets by the same manufacturer.

Aims and objectives

- To evaluate slot depth and slot width of four commercially available brackets by different manufacturers
- To compare and assess the variation between reported and actual slot dimensions of various commercially available brackets.
- To assess gross surface irregularities using microscopic images, and also to assess the slot geometry of the brackets

MATERIALS AND METHODS

The materials for this study comprised of 100 upper right central incisor brackets, manufactured by four different manufacturers

- 3M UNITEK™ Gemini Metal Brackets
- American Orthodontics Masters Series Brackets
- Chirpans orthodontics- Eco- plus Stainless Steel Bracket System
- Modern Orthodontics Sapphire Series Brackets
- Equipment used Confocal microscope (Olympus 5800) powered by LEXT software
- Modelling clay
- Each bracket was individually mounted on microscope table using modelling clay, bracket slot was oriented vertically on slide so that the line of view of the measuring microscope is parallel to the slot axis. The slide was then placed on the microscope table and adjusted until a sharp, well-focused image is viewed. Two sets of images one laser image and one light microscopic image were captured.
- The dimensions of slot were measured from the laser images generated by con focal microscope using inbuilt measuring software (LEXT). The dimensions measured were slot top, slot base, and walls of the slot. All the four dimensions were measured for all the brackets and the values were recorded and tabulated and subjected to statistical analysis. The slot irregularities were examined using light microscopic images generated by con focal microscope.

RESULTS

The brackets were examined under con-focal microscope and measured for slot width at base and top and depth at slot at the walls respectively and the depth from the slot point was calculated (Image 1). Comparison of slot width at base showed that and the mean width at slot base was 0.0228 inch in Gemini, 0.0214 inch in Mini-masters, 0.0277inch in Eco-plus and 0.0217 inch in Sapphire (Graph 1). The data was subjected to ANOVA and Bonferroni post hoc analysis, there was statistically significant difference between all the groups except Mini masters and Sapphire brackets (p=0.396) (Table-1).

- Slot dimension at base
- Slot dimension at top
- Slot depth at wall (1)
- Slot depth at wall (2)

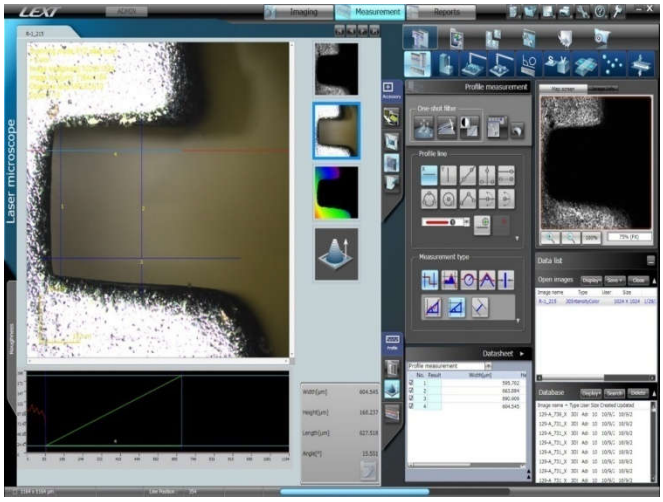
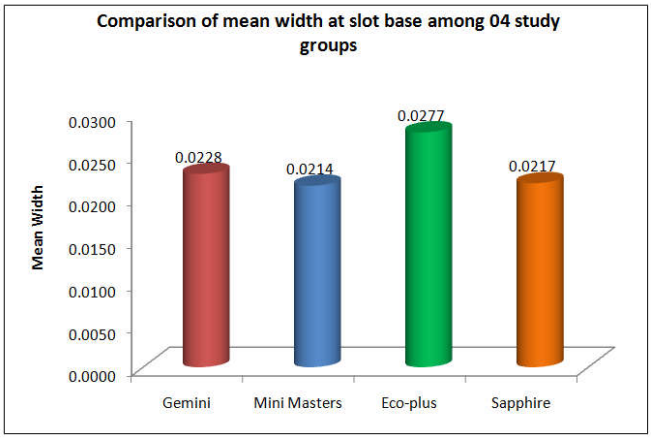


Image 1. Image of screen measuring slot dimensions

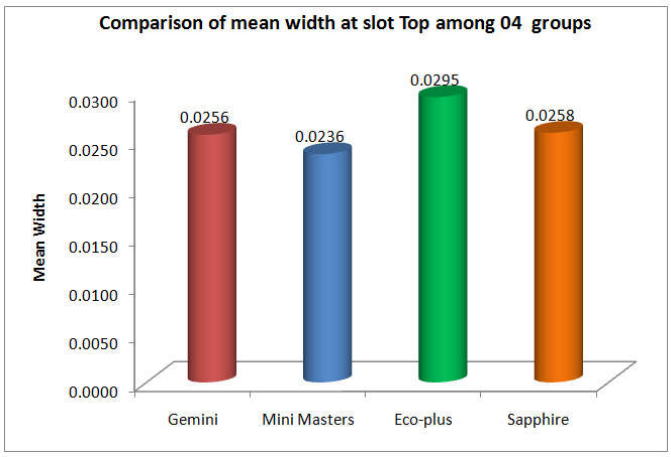


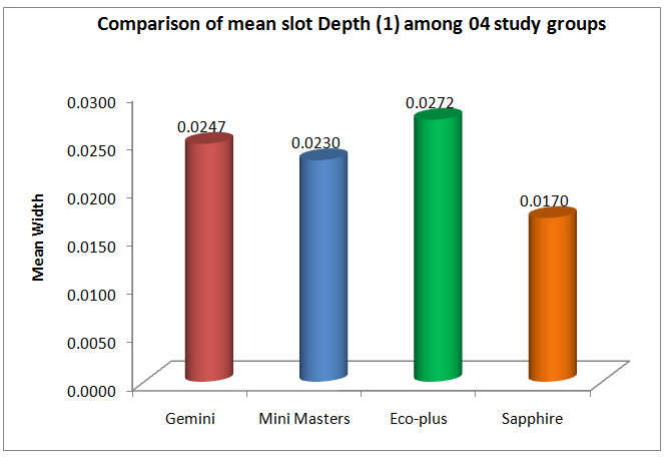
Graph 1. Comparison of slot width at base among four groups

Table 1. Comparison of mean width at slot base among four groups using ANOVA test followed by Bonferroni Post hoc Analysis

Comparison of mean width at slot base among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis											
Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	P-Value	Sig. Diff	P-Value
					Lower	Upper					
Gemini	25	0.0228	0.0008	0.0002	0.0202	0.0230	0.0199	0.0234	<0.001*	A Vs B	<0.001*
										B Vs C	
Mini-masters	25	0.0214	0.0007	0.0001	0.0206	0.0222	0.0199	0.0230		A Vs C	<0.001*
										B Vs D	0.396
Eco-plus	25	0.0277	0.0030	0.0002	0.0234	0.0311	0.0227	0.0320		A Vs D	0,0022*
Sapphire	25	0.0217	0.0015	0.0002	0.0187	0.0231	0.0176	0.0239		C Vs D	<0.001*

Comparison of slot width at top was done among 4 groups, and the mean width at slot top was 0.0256inch in Gemini, 0.0236inch in Mini masters, 0.0295inch in Eco-plus and 0.0258inch in Sapphire (Graph-2). There was statistically significant difference between all the groups except Mini masters and Sapphire brackets (p=0.55) (Table 2).Comparison of slot depth at wall (1) was done among 4 groups, and the mean depth a was 0.0247inch in Gemini, 0.0230 inch in Mini





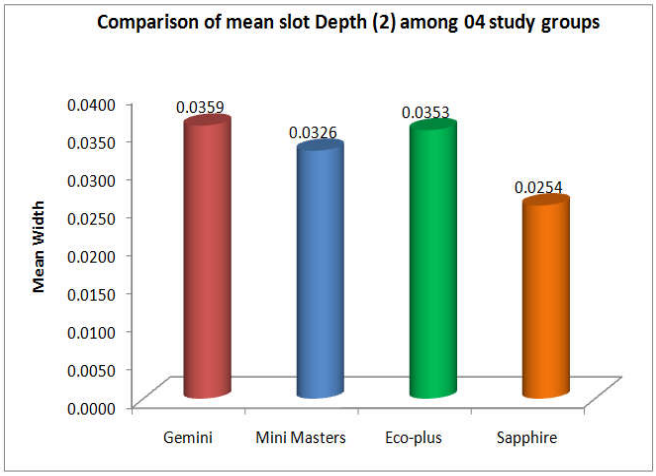
Graph 2. Comparison of slot width at topGraph 3. Comparison of mean slot depth from slot wall (1)

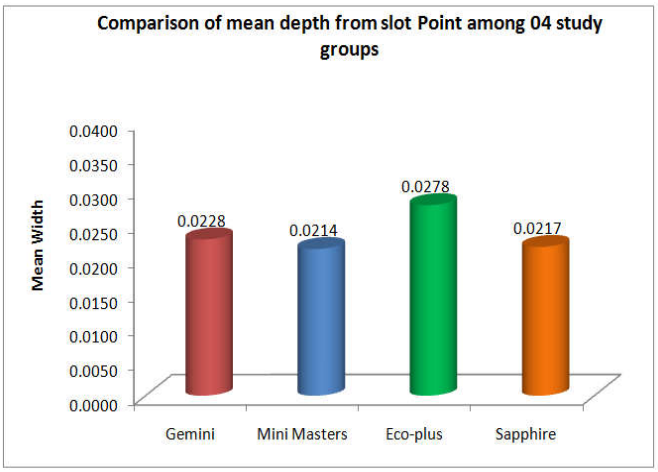
Table 2. Comparison of mean width at slot Top among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis

Comparison of mean width at slot Top among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis											
Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	P-Value	Sig. Diff	P-Value
					Lower	Upper					
Gemini	25	0.0256	0.0012	0.0005	0.0250	0.0274	0.0232	0.0282	<0.001*	A Vs B B Vs C	
Mini-masters	25	0.0236	0.0005	0.0003	0.0234	0.0240	0.0224	0.0248		A Vs C B Vs D	<0.001*
Eco-plus	25	0.0295	0.0035	0.0002	0.0254	0.0322	0.0244	0.0342		C Vs D	<0.001*
Sapphire	25	0.0258	0.0012	0.0002	0.0241	0.0261	0.0233	0.0279		A Vs D	0.55

Table 3. Comparison of mean slot Depth (1) among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis

Comparison of mean slot Depth (1) among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis											
Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	P-Value	Sig. Diff	P-Value
					Lower	Upper					
Gemini	25	0.0247	0.0008	0.0009	0.0240	0.0252	0.0233	0.0266	<0.001*	A Vs B B Vs C	<0.001*
Mini-masters	25	0.0230	0.0014	0.0006	0.0217	0.0244	0.0205	0.0263		A Vs C B Vs D	<0.001*
Eco-plus	25	0.0272	0.0045	0.0003	0.0213	0.0317	0.0206	0.0328		A Vs D	<0.001*
Sapphire	25	0.0170	0.0019	0.0003	0.0141	0.0211	0.0132	0.0215		C Vs D	





Graph 4. Comparison of mean slot depth from slot wall (2)

Graph 5. Comparison of mean depth from slot point

masters, 0.0272inch in Eco-plus and 0.0170inch in Sapphire (Graph-3). There was statistically significant difference between all the groups ($p<0.001$) (Table-3). Comparison of slot depth at wall (2) was done among 4 groups, and the mean depth a was 0.0359inch in Gemini, 0.0326inch in Mini masters, 0.0353inch in Eco-plus and 0.0254 inch in Sapphire (Graph-4).

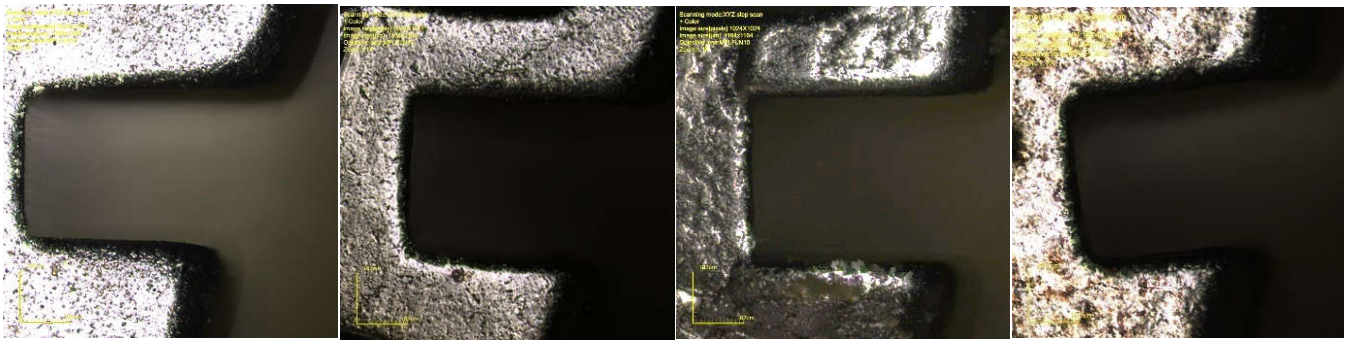
There was statistically significant difference between all the groups except Gemini and Eco-plus brackets ($p = 0.65$). Slot depth from slot point was calculated and comparison of slot depth from slot point was done among 4 groups, and the mean depth a was 0.0303inch in Gemini, 0.0278 inch in Mini masters, 0.0313inch in Eco-plus and 0.0212inch in Sapphire (Graph-5).

Table 4. Comparison of mean slot Depth (2) among four study groups using ANOVA test followed by Bonferroni Post hoc Analysis

Comparison of mean slot Depth (2) among four study groups using ANOVA test followed by Bonferroni Post hoc Analysis											
Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	P-Value	Sig. Diff	P-Value
					Lower	Upper					
Gemini	25	0.0359	0.0015	0.0011	0.0318	0.0385	0.0315	0.0389	<0.001*	A Vs B	<0.001*
										B Vs C	
Mini-masters	25	0.0326	0.0018	0.0004	0.0265	0.0338	0.0246	0.0342		A Vs C	0.65
										B Vs D	<0.001*
Eco-plus	25	0.0353	0.0064	0.0003	0.0270	0.0416	0.0259	0.0427		A Vs D	<0.001*
Sapphire	25	0.0254	0.0020	0.0003	0.0232	0.0282	0.0217	0.0297		C Vs D	

Table 5. Comparison of mean depth from slot point among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis

Comparison of mean depth from slot point among 04 study groups using ANOVA test followed by Bonferroni Post hoc Analysis											
Study Groups	N	Mean	SD	Std. Error	95% CI for Mean		Minimum	Maximum	P-Value	Sig. Diff	P-Value
					Lower	Upper					
Gemini	25	0.0303	0.0049	0.0007	0.0287	0.0317	0.0280	0.0324	<0.001*	A Vs B	<0.001*
										B Vs C	
Mini-masters	25	0.0278	0.0013	0.0004	0.0273	0.0291	0.0264	0.0302		A Vs C	0.4962
										B Vs D	<0.001*
Eco-plus	25	0.0313	0.0054	0.0002	0.0245	0.0361	0.0243	0.0378		A Vs D	<0.001*
Sapphire	25	0.0212	0.0017	0.0002	0.0190	0.0243	0.0178	0.0256		C Vs D	



a. Gemini **b.Mini Masters** **c. Eco plus** **d. Sapphire**

Image 2. Bracket slot images seen through con focal microscope

There was statistically significant difference between all the groups except Gemini and Eco-plus brackets (p =0.496). All the brackets slot dimensions were different, none of the brackets by the same manufacturer or the brackets of different manufacturer had similar slot dimensions. On examining the microscopic images it was found that Gemini and Mini masters brackets had better surface finishing , eco plus and sapphire brackets had lot of surface irregularities. All the bracket slots had convergent bases, slot dimension at the top was higher than that of slot dimension at the base in all the brackets.

DISCUSSION

The results of this study are in agreement with the study done by Kusy *et al*. (1999), Vinaya *et al*, (Pai, 2004), that orthodontic bracket slots are mostly larger than stated by the manufacturers. Slot geometry and the standard of bracket finish varied greatly between the bracket groups. In the studies by Kusy*et al*. (1999) and Vinaya *et al*. (Pai, 2004), they found that all the brackets slot were either convergent divergent or parallel but in our study we found all the brackets. had convergent slots,that is slot top was of higher dimension than that of the slot base, the slot geometry is trapezoidal, not rectangular as an per orthodontists expectations.Undersized brackets were seen similar to findings by Brown *et al* (Brown, 2015).In his study on complete bracket series he found that 36% of the slots would not be large enough to insert a full-size wire.

In our study we found that 30% of the brackets were undersized. Size of bracket slot were different even among the brackets by same manufacturer, that is to say no two brackets had similar slotsSiatkowski (Siatkowski, 2010) suggested the effects of anterior torque force loss with brackets with a bigger than necessary slot size, he noted that maxillary and mandibular incisors may suffer an unexpected loss of torque force of 5-10°, and this is compared to 1.9 millimeters of lingual retrusion during retraction to close residual spaces. Major *et al.* (Major, 2010) noted the manufacturing defects in orthodontic brackets, we also noted similar findings. There was considerable variation in the finishing standards between all the different groups of brackets and, to a lesser extent, within bracket groups, Gemini and mini masters brackets had good finishing. Most of the brackets had voids, all the manufacturers provided brackets manufactured with metal injection moulding technique, which should reduce the chances of manufacturing defects still we noticed only Gemini and mini masters brackets had less of voids in the bracket slot, Major *et al.* (Major, 2010) states that the clinician using the defective bracket cannot have optimal tooth position, in his study he noted that manufacturing defects occurred both as a single anomaly as well as throughout the entire tooth-specific set of brackets in a series. He stated that if bracket is defective it may not give a desired result in such scenarios, it is possible one would assume that bracket positioning is wrong and would simply be rebonding a similarly defective bracket, and if that happens the tooth position could potentially become even less optimal.

Conclusion

- The actual slot size and shape of an orthodontic bracket are likely to vary both larger and smaller from the advertised nominal value, (ranging from 0.017- 0.031 inches) within a bracket series.
- Slot geometry and the standard of bracket finish varied greatly between the bracket groups and brackets of same group.
- Clinicians should be aware that there may be a three-dimensional loss of tooth positioning as a result of the inadvertent use of orthodontic brackets with oversized slots.
- If brackets are oversized using conventional wire sizes and a straight wire approach, some brackets marketed as preadjusted clearly would not able to produce a torqueing tooth movement without additional wire bending
- Undersized brackets would not be able to incorporate full size arch wires, compromising mechanics.

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