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Comparative assessment of the accuracy of ceramic orthodontic brackets to 0.022-inch stainless steel slots in orthodontic patients

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***Abstract*---**Background: Brackets are the passive components that transfer the force to the teeth by elastomeric chains, springs, and the arch wire. The arch wire placement in a bracket that is pre-adjusted is done to construct three-dimensional forces to move the tooth. Aim: The present study was conducted to compare and assess the accuracy of ceramic orthodontic brackets to 0.022-inch stainless steel slots in orthodontic patients. Materials and Methods: The present in-vitro study included a maxillary lateral incisor of the left side where 0.022 MBT American orthodontics (AO) slots as placed with 15 ceramic and 15 stainless steel brackets were placed and divided into 6 groups of 90 subjects. Software analysis was done to assess distal face and base, mesial face and base. Results: For the stainless-steel group, a statistically significant higher slot width was seen for 3M Unitek compared to Ormco and American Orthodontics (AO) slots with $p<0.05$. Concerning ceramic brackets, higher slot width was seen for American Orthodontics (AO) slots compared to 3M Unitek and Ormco ceramic brackets. This difference was statistically significant with

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p<0.05. Conclusion: The present study concludes that inaccuracies in dimensions are seen owing to the existing difference between measured values and stated values. A comprehensible approximation concerning appliances might be required during the detailing and finishing stage to prevent torque loss owing to divergence of slot walls and oversize of slots.

***Keywords*---**ceramic bracket, distal face base, mesial face base, stainless steel bracket, slot width, stereomicroscope.

Introduction

In orthodontic practice, a bracket by Raymond C Thurow is defined as an attachment placed on a tooth for engaging the archwire. Brackets are the passive components that transfer the force to the teeth by elastomeric chains, springs, and the archwire. The archwire placement in a bracket that is preadjusted is done to construct three-dimensional forces to move the tooth. These three-dimensional forces are generated from intimate wire fit to the bracket slot. Any slop or play between these components leads to less force transmission of the bracket prescription to the supporting tissues of the teeth and tooth itself.[1]

To attain technological progress, standardization is the requirement. With the advancements in the field of technology and orthodontics, two different orthodontic bracket slot sizes were evolved which allows the orthodontist to choose the appropriate size based on the malocclusion of the subject being treated. The two available dimensions are 0.018 inches (0.4572 mm) and 0.022 inches, which have a difference of four-thousandths of an inch showing an unusual metric description in the modern era where the measurements are done in micrometers and millimeters.[2]

The final three-dimensional tooth position is inversely affected by oversized brackets and undersized wires with ample literature data focusing on this aspect. The exact description of SI unit standardization and slot geometry is vital in Orthodontics as suggested by Kusy and Whitley. Another vital factor is the binding angle, as the contact angle between bracket and archwire increases the sliding mechanic's resistance. Concerning the dimension of the bracket slots, there should be a precise archwire dimension. The difference in the size of slot and manufacturing process irregularity in brackets might result in improper archwire engagement resulting in torque control loss.[3]

The present study was conducted to measure and assess the accuracy of ceramic orthodontic brackets to 0.022-inch stainless steel slots in orthodontic patients from different manufacturers both at the base and top of the slot and to assess the variation extent between actual and reported slot width.

Materials and Methods

The present study was conducted to measure and assess the accuracy of ceramic orthodontic brackets to 0.022-inch stainless steel slots in orthodontic patients

from different manufacturers both at the base and top of the slot and to assess the variation extent between actual and reported slot width.

The study samples were contributed by the extracted maxillary left central incisors collected from the Institute. For the present study, 15 ceramic and stainless-steel brackets of MBT 0.022-inch slot from 3 different manufacturers were used including Ormco, 3M Unitek, and AO (Americal Orthodontics) were randomly selected and the slot dimensions were evaluated. The total sample size was 90 brackets that were divided into 15 teeth in each group.

With the help of modeling clay, each bracket was placed in the proper position on the white cardboard to attain stability and was marked from number 1 to 15 to attain a clear slot wall view from the bracket side on viewing under the stereomicroscope. For easy identification, the slots from number 1 to 15 were marked as Ormco, 3M unitek, and AO (American orthodontics) for both ceramic and stainless steel brackets. Under the stereomicroscope of magnification 40X, the brackets were viewed. The scanning of each bracket was done and they were individually captured on both distal and mesial sides to get slot size digital imaging. The images obtained were then calibrated with the image analysis software.

On the bracket face, two points were marked on the inferior and superior end, and in the same manner, two points were marked on the base on its inferior and superior ends. This resulted in the automatic production of options to get an accurate point which allows appropriate calculation of slot dimensions at the base and the face of the bracket. The images with the dimensions of ceramic brackets and stainless-steel brackets at distal and mesial sides at the base and face were captured and stored.

The bracket dimensions from face to base were assessed on both distal and mesial sides and were compared between ceramic and stainless-steel brackets of 3M Unitek, Ormco, and AO brackets. The comparison between three types was done between ceramic and stainless-steel brackets of three groups for 3M Unitek, Ormco, and AO at the distal and mesial base and face. The dimensions obtained from the study were compared to the manufacturer's dimensions and were compared to the standard values. The collected data were subjected to the statistical evaluation using SPSS software version 21 (Chicago, IL, USA) for results formulation. The data were expressed in percentage and number. The level of significance was kept at $p<0.05$.

Results

The study results have shown that slot widths were higher in comparison to the standard values for the brackets. The study results have also shown that stainless-steel brackets had significantly higher dimensions for the distal base, mesial base, and mesial face when compared to the standard values with $p<0.05$. Intergroup comparison also showed that significantly higher slot widths were seen for 3M Unitek brackets compared to AO and Ormco brackets. For the mesial face of the stainless-steel brackets, the mean dimensions for 3M Unitek, Ormco, American Orthodontics, and standard bracket were 0.563152±0.00165,

0.561402±0.0022574, 0.561852±0.0022544, and 0.558800 which was statistically significant with p<0.001 with higher dimensions as shown in Table 1.

On intergroup comparison of stainless-steel mesial face, 3M Unitek brackets, the mean difference with standard, AO, and Ormco were 0.0043500±0.0005667, 0.0013000±0.0005667, and 0.0017500±0.0005667 respectively which was statistically significant for standard and Ormco with p-values of 0.000 and 0.01 respectively. For Ormco, the mean differences for standard, AO, and 3M Unitek were 0.0026000±0.0005667, −0.0004500±0.0005667, and −0.0017500±0.0005667 respectively which was significant for standard and 3M Unitek with respective p-values of 0.000 and 0.01 respectively. Concerning American Orthodontics, mean differences against the standard, Ormco, and 3M Unitek were 0.0030500±0.0005665, 0.0004500±0.0005665, and −0.0013000±0.0005665 which was significant for standard with p=0.000. On comparing the standard bracket dimensions against AO, Ormco, and 3M Unitek with respective mean differences of −0.0030500±0.0005665, −0.0026000±0.0005665, and −0.0043500±0.0005665 respectively which was significantly lesser than all other brackets with a p-value of 0.000 (Table 2).

Concerning the intergroup comparison of the distal face of ceramic brackets, for 3M Unitek, the mean differences for standard, AO, and Ormco were 0.0008500±0.0005875, −0.0018500±0.0005875, and 0.0003000±0.0005875 respectively which was significant for AO with p=0.01. For Ormco, mean differences for standard, AO, and 3M Unitek respectively were 0.0005500±0.0005875, −0.0021500±0.0005875, and −0.0003000±0.0005875 respectively which was statistically significant for AO only with p=0.003. For AO, the mean differences for standard, Ormco, and 3M Unitek were 0.0027000±0.0005875, 0.0021500±0.0005875, and 0.0018500±0.0005875 respectively. This was statistically significant for all the brackets with respective p-values of 0.000, 0.003, and 0.01. On comparing the standard against AO, Ormco, and 3M Unitek, the mean differences were −0.0027000±0.0005875, −0.0005500±0.0005875, and −0.0008500±0.0005875 respectively which was statistically significant for AO only with p=0.000 as shown in Table 3.

Discussion

The present study was conducted to measure and assess the accuracy of ceramic orthodontic brackets to 0.022-inch stainless steel slots in orthodontic patients from different manufacturers both at the base and top of the slot and to assess the variation extent between actual and reported slot width. The study results have shown that slot widths were higher in comparison to the standard values for the brackets. The study results have also shown that stainless-steel brackets had significantly higher dimensions for the distal base, mesial base, and mesial face when compared to the standard values with p<0.05. Intergroup comparison also showed that significantly higher slot widths were seen for 3M Unitek brackets compared to AO and Ormco brackets. For the mesial face of the stainless-steel brackets, the mean dimensions for 3M Unitek, Ormco, American Orthodontics, and standard bracket were 0.563152±0.00165, 0.561402±0.0022574, 0.561852±0.0022544, and 0.558800 which was statistically significant with p<0.001 with higher dimensions. These results were consistent with the findings

of Brown P et al[4] in 2015 and Tangri K et al[5] in 2012 where authors reported significantly higher dimensions of stainless-steel brackets for the distal base, mesial base, and mesial face when compared to the standard values.

Concerning the intergroup comparison of stainless-steel mesial face, 3M Unitek brackets, the mean difference with standard, AO, and Ormco were 0.0043500±0.0005667, 0.0013000±0.0005667, and 0.0017500±0.0005667 respectively which was statistically significant for standard and Ormco with p-values of 0.000 and 0.01 respectively. For Ormco, the mean differences for standard, AO, and 3M Unitek were 0.0026000±0.0005667, −0.0004500±0.0005667, and −0.0017500±0.0005667 respectively which was significant for standard and 3M Unitek with respective p-values of 0.000 and 0.01 respectively. Concerning American Orthodontics, mean differences against the standard, Ormco, and 3M Unitek were 0.0030500±0.0005665, 0.0004500±0.0005665, and −0.0013000±0.0005665 which was significant for standard with p=0.000. On comparing the standard bracket dimensions against AO, Ormco, and 3M Unitek with respective mean differences of −0.0030500±0.0005665, −0.0026000±0.0005665, and −0.0043500±0.0005665 respectively which was significantly lesser than all other brackets with a p-value of 0.000. These results were in agreement with the studies of Pai VS et al[6] in 2011 and Major TW et al[7] in 2010 where authors reported similar values for stainless-steel mesial face on comparing with 3M Unitek, Ormco, and AO brackets.

On the intergroup comparison of the distal face of ceramic brackets, for 3M Unitek, the mean differences for standard, AO, and Ormco were 0.0008500±0.0005875, −0.0018500±0.0005875, and 0.0003000±0.0005875 respectively which was significant for AO with p=0.01. For Ormco, mean differences for standard, AO, and 3M Unitek respectively were 0.0005500±0.0005875, −0.0021500±0.0005875, and −0.0003000±0.0005875 respectively which was statistically significant for AO only with p=0.003. For AO, the mean differences for standard, Ormco, and 3M Unitek were 0.0027000±0.0005875, 0.0021500±0.0005875, and 0.0018500±0.0005875 respectively. This was statistically significant for all the brackets with respective p-values of 0.000, 0.003, and 0.01. On comparing the standard against AO, Ormco, and 3M Unitek, the mean differences were −0.0027000±0.0005875, −0.0005500±0.0005875, and −0.0008500±0.0005875 respectively which was statistically significant for AO only with p=0.000. These findings were similar to the results of Bhalla NB et al[8] in 2010 and McLAughlin RP et al[9] in 2015 where authors showed similar values on intergroup comparison of ceramic bracket distal face as in the present study.

Conclusion

Within its limitations, the present study concludes that inaccuracies in dimensions are seen owing to the existing difference between measured values and stated values. A comprehensible approximation concerning appliances might be required during the detailing and finishing stage to prevent torque loss owing to divergence of slot walls and oversize of slots. However, the present study had a few limitations including a smaller sample size, geographical area biases, recall bias, and single-institution nature. Hence, more longitudinal and prospective

studies with larger sample sizes, and longer monitoring periods are needed to reach a definitive conclusion.

Conflicts of interest: nil

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Tables

Bracket dimensions	Type	N	Dimensions (Mean± S. D)	p-value
Mesial face (stainless-steel)	3M Unitek	15	0.563152±0.00165	
	Ormco	15	0.561402±0.0022574	
	American Orthodontics	15	0.561852±0.0022544	
	Standard	15	0.558800	
Distal face (Ceramic)	3M Unitek	15	0.559652±0.0021097	<0.001
	Ormco	15	0.559352±0.0023460	
	American Orthodontics	15	0.561502±0.0019603	
	Standard	15	0.558800	

Table 1: Mean slot width comparison of stainless-steel bracket for the mesial and ceramic brackets for distal face in different brackets

Group	Intergroup comparison	Mean Difference	p-value
3 M Unitek	Standard	0.0043500±0.0005667	0.000
	American Orthodontics	0.0013000±0.0005667	0.107
	Ormco	0.0017500±0.0005667	0.01
Ormco	Standard	0.0026000±0.0005667	0.000
	American Orthodontics	−0.0004500±0.0005667	0.859
	3 M Unitek	−0.0017500±0.0005667	0.01
American Orthodontics	Standard	0.0030500±0.0005665	0.000
	Ormco	0.0004500±0.0005665	0.859
	3 M Unitek	−0.0013000±0.0005665	0.109
Standard	American Orthodontics	−0.0030500±0.0005665	0.000
	Ormco	−0.0026000±0.0005665	0.000
	3 M Unitek	−0.0043500±0.0005665	0.000

Table 2: Mean slot width comparison of stainless-steel bracket for the mesial face using post-hoc analysis

Group	Intergroup comparison	Mean Difference	p-value
3 M Unitek	Standard	0.0008500±0.0005875	0.476
	American Orthodontics	−0.0018500±0.0005875	0.01
	Ormco	0.0003000±0.0005875	0.958
Ormco	Standard	0.0005500±0.0005875	0.787
	American Orthodontics	−0.0021500±0.0005875	0.003
	3 M Unitek	−0.0003000±0.0005875	0.958
American Orthodontics	Standard	0.0027000±0.0005875	0.000
	Ormco	0.0021500±0.0005875	0.003
	3 M Unitek	0.0018500±0.0005875	0.01
Standard	American Orthodontics	−0.0027000±0.0005875	0.000
	Ormco	−0.0005500±0.0005875	0.787
	3 M Unitek	−0.0008500±0.0005875	0.476

Table 3: Mean slot width comparison of ceramic bracket for the distal face using post-hoc analysis