



Evaluation of Different Bracket's Resistance to Torsional Forces from Archwire

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ABSTRACT

Aim: The present study was aimed to evaluate the resistance to deformation or fracture of brackets of various materials (ceramic, ceramic reinforced with metal slot, and stainless steel brackets) with archwires during application of torque.

Materials and methods: The sample size included 30 brackets of maxillary right central incisor with slot dimension of 0.022×0.028" and made of three materials (10 of each type): (1) Ceramic brackets (cer), (2) ceramic brackets reinforced with stainless steel slot (cer/ss), and (3) stainless steel brackets (metal). Thirty stainless steel archwire segments of 0.019×0.025" SS 5 cm in length were used. Elastomeric ties were also used in this study.

Results: Highest to lowest deformation or fracture torque found is as follows: Stainless steel brackets (5713.2 gfmm), metal ceramic reinforced with metal slot brackets (4080.8 gfmm), and ceramic brackets (3476 gfmm).

Conclusion: Stainless steel brackets showed significantly higher values of torsional load than ceramic brackets reinforced with metal slot and ceramic brackets.

Clinical significance: Clinically orthodontic treatment is based on specific force applications to the dentition, the maxilla and

the mandible. In order to obtain these forces, orthodontic brackets are attached to the teeth. Most commonly used brackets are metal (stainless steel), ceramic, and combination of metal reinforced ceramic brackets. For successful orthodontic treatment, it is necessary to maintain proper torque and avoid torque loss. Torque loss leads to deepening of bite. Torque loss occurs due to many reasons, one of them being bracket failure to withstand applied torque.

Keywords: Ceramic brackets, Ceramic reinforced with metal slot bracket, Stainless steel brackets, Torque.

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INTRODUCTION

Orthodontic tooth movement is made possible by the fact that tooth can be moved through alveolar bone by applying appropriate forces. Brackets are merely handles for attachment of the force producing agents. Orthodontic treatment is based on specific force applications to the dentition, the maxilla and the mandible. In order to obtain these forces, orthodontic brackets are attached to the teeth. The most commonly used brackets are stainless steel (metal), ceramic, and combination of metal reinforced ceramic brackets.

The ceramic brackets offer improved esthetics and are well suited to the oral environment. Their acceptance by patients has been known in the practice of orthodontics. The fracture of ceramic brackets from archwire tipping and torquing forces has been reported to be a problem by the orthodontic profession. Bracket fracture contributes to increased chair time, patient discomfort, and the potential health hazard of aspirating a bracket fragment.

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Because there is virtually no plastic deformation seen in ceramic materials that could relieve these stresses at the tips of the cracks, the cracks propagate until total structural failure occurs.¹ Fracture toughness, the ability of a material to resist fracture along a crack or groove, is an important property of ceramics. In order to evaluate brackets, the physical and mechanical properties of their materials must be understood.² The finishing techniques can cause microcracks, which can make the brackets more susceptible to fracture. All aspects of any new material should be investigated before its clinical application to prevent undesired side effects.³ Therefore, it is necessary to compare actual brackets, rather than bracket materials.⁴ Fracture toughness in ceramics is 20 to 40 times less than in stainless steel,^{5,6} making it much easier to fracture a ceramic bracket than a metallic one. Third-order wire activations (torque) may be more likely to cause ceramic bracket failure.^{7,8}

Torque can be defined from a mechanical or a clinical point of view. Mechanically, it refers to the twisting of a structure about its longitudinal axis, resulting in an angle of twist.⁹ Torque is a shear-based moment that causes rotation. Clinically, in orthodontics, it represents the bucco-palatal crown/root inclination of a tooth. When applied in an orthodontic archwire/bracket interaction, it describes the activation generated by twisting an archwire in a bracket slot.

Clinically, torque control is often required in the maxillary incisors for an ideal inter-incisal angle, adequate incisor contact, and sagittal adjustment of the dentition in order to achieve an ideal occlusion.¹⁰ Considerable work has been done on deformation and fracture resistance of ceramic and polycarbonate brackets. Efforts to measure deformation of stainless steel brackets in response to torsional forces have been lacking.

The present study is an attempt to evaluate the resistance to deformation or fracture of brackets of various materials (ceramic, ceramic reinforced with metal slot, and stainless steel brackets) with archwires during application of torque.

MATERIALS AND METHODS

The present study consisted of 30 preadjusted edge-wise brackets. Ten brackets for the maxillary right central incisor with slot dimension of 0.022×0.028 and made of three different materials were used: (1) Ceramic brackets (cer), (2) ceramic brackets reinforced with metal slot (cer/ss), and (3) stainless steel brackets (metal) (Table 1). All brackets had built-in torque as per MBT prescription, i.e., $+17^\circ$. Thirty stainless steel archwire segments of 0.019×0.025 5 cm in length were also used in this study. The stainless steel archwire was ligated

onto the brackets with elastomeric ties. Two types of bases were constructed with same tip and torque angulations: 0° tip & $/0^\circ$ torque. The purposes of the bases were to compensate for the different dimensions of ceramic and metal brackets.

The brackets were fixed onto the respective bases with Fevikwik (Pidilite Industries Ltd, Mumbai, India) and hooks to hold the brackets' base.

Custom apparatus (Fig. 1) for study: Supporting posts were used to mount a crossbar that could hold and twist the wire without displacement in another direction. Ligature wire was fastened to the crossbar for twisting the archwire. The opposite crossbar held the other end of the archwire in place and rotated simultaneously in the same direction. The end of the ligature wire was attached to a load cell of 250 kgf on top of the Instron testing machine (DAC System Inc., Series 9000 model 60001/333522) and standardized with a crosshead speed of 1 inch per minute. The mechanical testing was done at Micro, Small & Medium Enterprises (MSME) testing center, Sanathnagar, Hyderabad (Government of India).

The bracket was placed 6 mm from the end of the crossbar wire holder to the mesial side of the bracket. This distance was standardized because it is considered to be an average interbracket distance between the maxillary incisors. The other end of the wire remained 24 mm from the tip of the opposite crossbar wire holder.

Table 1: Details of material

Brackets	Archwires	Ligature
Ceramic (Gemini clear MBT 022, 3M Unitek)	19 × 25 Stainless steel (Ortho Organizer Carlsbad, CA)	Elastomeric ties (Ortho Organizer Carlsbad, CA)
Ceramic reinforced with metal (Clarity MBT 022, 3M Unitek)		
Steel (Gemini MBT 022, 3M Unitek)		



Fig. 1: Custom apparatus

Table 2: Comparison of mean fracture load or deformation strength of ceramic brackets, ceramic brackets reinforced with metal slot, and stainless steel brackets with 0.019 × 0.025" SS archwire

Archwire	Variable	No. of samples	Mean (gfmm)	Standard deviation	F-statistic	p-value
0.019 × 0.025	Ceramic brackets	10	3476.00	37.2	8315.87	0.000*
	Ceramic brackets reinforced with metal slot	10	4080.80	31.5		
	Stainless steel brackets	10	5713.20	49.4		

*Statistically significant

The stainless steel archwire was ligated onto the brackets with elastomeric ties.

Each bracket-wire combination was randomly selected. Before the measurements, each combination was cleaned with surgical spirit to remove surface contamination and dried with air spray. The mechanical test was executed with gradual torsion applied to the archwire until the bracket deformed or fractured.

The amount of force (kf) exerted by the ligature was recorded. The highest point on the recording chart was regarded as the moment of bracket fracture or deformation. To obtain the torque in gram-millimeters, the force was multiplied by the radius of the crossbar (4 mm), according to the following equation: $T = F \times r$, where T = torque, F = force obtained, and r = radius of the crossbar.

RESULTS

The fracture load values obtained for all samples were calculated in gfmm by formula $T = F \times r$, where T = torque, F = force obtained, and r = radius of the crossbar. The gfmm values for all the groups were entered in Microsoft excel sheet (Microsoft Corporation, Washington, USA) and it was subjected to statistical analysis SPSS-16 (Statistical Product and Service Solutions-Version 16).

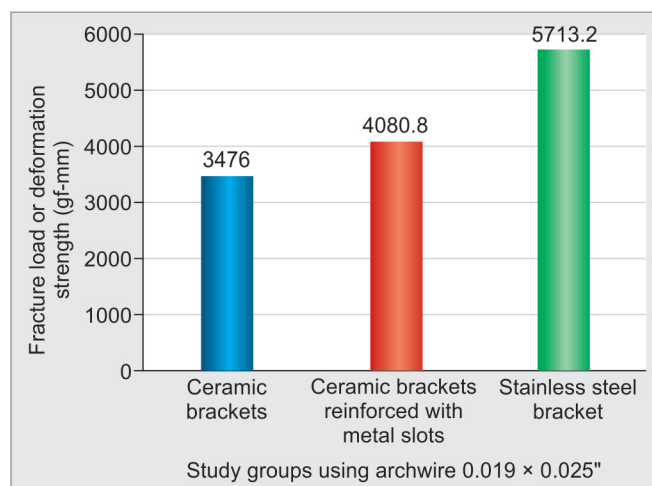
Analysis of variance (ANOVA) test was applied to statistically compare mean fracture load or deformation strength applied by the 0.019 × 0.025" SS archwire with ceramic brackets, ceramic brackets reinforced with metal slot, and stainless steel brackets.

Table 2 shows there was statistically significant difference in mean fracture load borne by ceramic brackets 3476 ± 37.2 gfmm (mean ± SD), ceramic reinforced with metal slot 4080.80 ± 31.5 gfmm (mean ± SD), stainless steel bracket 5713.20 ± 49.4 gfmm (mean ± SD), when three groups were compared with 0.019 × 0.025" SS archwire with "p-value" < 0.05.

Graph 1 shows comparison of mean fracture load or deformation strength of ceramic, ceramic reinforced with metal slot, and stainless steel brackets with 0.019 × 0.025" SS archwires.

DISCUSSION

In the present study, the fracture load of ceramic brackets using 0.019 × 0.025" SS archwire was 3476 ± 37.23 gfmm



Graph 1: Comparison of mean fracture load or deformation strength of brackets using 0.019 × 0.025" SS archwires

(mean ± SD). These values are similar when compared to studies conducted by Morina et al¹¹ using 0.019 × 0.025" SS archwire [3630.2 ± 285.2 gfmm (mean ± SD)].

In the present study, the fracture load value with stainless steel brackets using 0.019 × 0.025" SS archwire was 5713.20 ± 49.49 gfmm (mean ± SD). This value was found to be much higher when compared to the value from a study conducted by Morina et al¹¹ 1254.25 gfmm (mean). The difference may be probably due to difference in testing apparatus used, the bracket manufacturer, and built-in torque.

In the present study the fracture or deformation load values of stainless steel bracket [5713.20 ± 49.49 gfmm (mean ± SD)], ceramic bracket [3476 ± 37.23 gfmm (mean ± SD)], and ceramic reinforced with metal slot bracket [4080 ± 31.54 gfmm (mean ± SD)] are different when 0.019 × 0.025" SS archwire was used. This difference in fracture load values can be explained by difference in material characteristics of the brackets used.¹²⁻¹⁵

In a clinical situation, the torquing moment transferred from the wire to the maxillary central incisor was 1035 to 2373 gfmm.¹⁶⁻¹⁸ Therefore, results of this study indicate that all brackets tested have enough resistance to deformation or fracture to incorporate torque to the maxillary central incisor using 0.019 × 0.025" SS archwire. All ceramic brackets reinforced with metal slot showed higher resistance to fracture than those without metal slot.

CLINICAL IMPLICATIONS OF THE PRESENT STUDY

In a clinical situation, the torquing moment transferred from the archwire to the maxillary central incisor was 1035–2373 gfmm.¹⁶⁻¹⁸ All types of brackets used in this study (ceramic, ceramic reinforced with metal slot, and stainless steel) have enough resistance to deformation or fracture to incorporate torque using archwire to the maxillary central incisor. In cases where extra torque is to be incorporated, it is always better to use steel brackets as they can withstand torsional forces better. Instead of ceramic brackets, ceramic brackets reinforced with metal slot are to be used, as they can withstand torque effectively.

SHORTCOMINGS OF THE STUDY

- The influence of factors like saliva, plaque, corrosion, chewing, bone density, tooth numbers, anatomic configurations, root surface area, and occlusion were not evaluated in this study.
- Effect of PH, enzymes, and oral microorganisms on the brackets' stability is still unknown.
- The effect of bracket deformation or fracture on adjacent teeth is yet another issue to be evaluated.

CONCLUSION

The present study concluded that stainless steel brackets showed significantly higher values of torsional load than ceramic brackets reinforced with metal slot and ceramic brackets. In addition, stainless steel bracket with 0.019 × 0.025" SS archwire was the best bracket archwire combination, out of the tested combinations, in achieving optimal torque.

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