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Evaluation Of Shear Bond Strength Of Ceramic Brackets With Two Different Base Designs: An In-Vitro Study

Research Article

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Abstract

Objectives: Ceramic brackets were introduced to satisfy the esthetic needs of the patient. The shear bond strength of the brackets is essential as it is important for bonding to enamel. The aim of the present study was to evaluate the shear bond strength (SBS) of ceramic orthodontic brackets with two distinctbase designs.
Methods: This was a prospective in-vitro study conducted in Saveetha Dental College and Hospitals, Chennai, India. 50 extracted premolar teeth and two groups of ceramic brackets with bead ball base design and mushroom shaped groove base design were used. 25 samples of each type of brackets were bonded onto 50 premolar teeth which were extracted for orthodontic purposes. Bonding was done using Transbond XT adhesive under standardized bonding procedures. After 24 hours, the shear bond test was done using a Universal testing machine. Descriptive statistics and independent sample t-test were done to compare the SBS of the two different bracket types. Significance value was set as 0.05.
Results: Mean shear bond strength of bead ball base brackets were 19.81 +/-3.81 MPa and mushroom shaped groove base brackets were 16.46 +/- 1.88 MPa. p-value < 0.01 was obtained as a result of the Independent sample t test.
Conclusion: SBS of ceramic brackets with bead ball base design was significantly more than that of the ceramic brackets with mushroom shaped groove base design.SBS of both the types of brackets were clinically acceptable.

Keywords: Shear Bond Strength; Ceramic Brackets; Base Designs.

Introduction

Recent times have seen an exponential increase in the rate of adult orthodontics and this in turn has increased the need for aesthetic or invisible orthodontic appliances. Invisible orthodontic appliances that gradually evolved into the field of orthodontics are the ceramic brackets, esthetic wires, lingual appliances and aligner trays. Although these appliances are aesthetically acceptable there are a few disadvantages like brittleness of the ceramic brackets, difficulty in oral hygiene maintenance in lingual appliances [1] and clinical efficacy of aligners in treating severe malocclusion [2], that need to be considered by the practitioner while choosing these appliances. Patient acceptance of the appliances will depend on the attractiveness, esthetic, comfort and economic value [3]. Considering the economic value, ceramic brackets are most commonly preferred by patients of low to middle socio-economic status, who comprise the major part of our population.

Ceramic brackets were introduced in the field of dentistry in the 1980s and were available for clinical use from 1987 [4]. From the day of introduction there were many modifications made in the bracket design by various manufacturers. Polycrystalline and monocrystalline are the two major types of ceramic brackets. They are named based on the difference in the process of manufacturing. The former is made from polycrystalline brackets whereas the latter is made from a single crystal alumina [5-7].

The bond strength of the ceramic brackets to enamel is signifi-

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cantly higher than that of the metal brackets. This bond strength can be attributed to the following characteristics of the brackets: mechanically retentive bases, silanized chemically retentive bases or both [8]. Many studies have shown that even though silanized bracket bases have more bond strength than mechanically retentive base brackets, the former cause more enamel fractures during the process of debonding [5-13]. Therefore, it is clinically favourable to use ceramic brackets with mechanically retentive bases than chemically retentive base designs.

In the literature there are a few studies comparing the bond strength of ceramic brackets of different base designs, namely, large round pits, irregular base, beads, grooves, microcrystalline base, and polymer mesh base [6-8, 14-16]. The present study was aimed to study the shear bond strength of ceramic brackets with two different base designs, which are, mushroom shaped grooves and patented bead ball design.

Materials and Methods

Teeth selection

Sample of 50 extracted premolar teeth were collected from the patients who reported to the Department of Orthodontics, Saveetha Dental College and Hospitals, Chennai. Orthodontic patients who were indicated for therapeutic extraction of the premolar teeth were included in the study. The study design was reviewed and approved by the Institutional Review Board.

The extracted teeth which had intact crowns with no fractures, attrition, decay or enamel hypoplasia were selected for the study. The teeth after extraction were cleaned with tap water to remove the soft tissue debris and were stored in 0.1% thymol solution to inhibit bacterial growth. Later it was stored in distilled water at 370C until use [8, 17].

Mounting the teeth

Mounting was done just before the bonding of the brackets on the teeth. The teeth were mounted on a base made of Type V gypsum product such that the entire crown of the teeth is exposed. Also the long axis of the tooth should be perpendicular to the floor in-order to facilitate proper bonding technique.

Ceramic brackets

The samples were randomly divided into two groups with 25 samples in each group. Ceramic brackets with patented bead ball design were bonded on group 1 samples and ceramic brackets with mushroom shaped groove base were bonded on group 2 samples. Group 1 ceramic brackets were microcrystalline type of brackets with base surface area of 11.50mm^2 and group 2 brackets were of polycrystalline type with a base surface area of 10.50mm^2.

Bonding technique

The following bonding technique was used for bonding the respective brackets on all the samples.

The extracted teeth after mounting on the base were cleaned and polished for 10 seconds with fluoride-free pumice slurry using a slow-speed contra-angled handpiece. The polished surface was rinsed with water and then air-dried [18]. After drying, the teeth were acid etched using 37% phosphoric acid for 15 seconds and flushed with water for 20 seconds. Then the teeth were dried until a 'frosty white'appearance was observed. A thin layer of primer was applied on the etched surface of the enamel; air dried for a second using a three way syringe and light cured for 3 seconds.

Transbond XT (Unitek/3M) adhesive was placed on the bracket base and the bracket was placed on the tooth. The bracket was positioned on the centre of the tooth such that the long axis of the bracket was parallel to the long axis of the tooth. The bracket was pressed over the buccal surface of the tooth so that a close contact was established between the bracket base and the surface of the tooth. The excess adhesive material was removed carefully from the sides of the bracket. The adhesive was light cured for 3 seconds on the mesial side and 3 seconds on the distal side.

The bonded specimens were stored in distilled water at 37°C for 24 hours and then subjected to shear bond strength testing.

Shear bond strength testing

Shear bond strength was tested on a universal testing machine (Model 3382, Instron Corp., Canton, Massachusetts, USA). The chisel for force application was attached to the upper jaw whereas the bonded specimens were attached to the lower jaw such that the direction of force was parallel to the bonded bracket base. The cross head speed was set at 1mm/minute and force was applied in an occluso-gingival direction. The maximum load of force at which the bracket-tooth interface disrupted was recorded in Newtons and then was converted to Megapascals [Bond strength in MPa = Force (Newton)/ Bracket surface area (mm^2)].

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics software version 20.0 for Windows. Descriptive statistics was done separately for both the groups. Independent sample student t-test was performed to compare the difference between the two groups. The level of statistical significance was defined at p value less than or equal to 0.05.

Results

Table 1 and 2 represent the results of descriptive statistics and student-t test respectively. Mean shear bond strength of bead ball base brackets were 19.81 +/-3.81 MPa and mushroom shaped groove base brackets were 16.46 +/- 1.88 MPa. There was a statistically significant difference in the shear bond strength among the two brackets with a p-value <0.01 for a confidence interval of 95%. Shear bond strength of bead ball base brackets were more than that of the mushroom shaped groove base brackets by a value of 3.35MPa.

Discussion

Ceramic brackets are one of the most economically favourable options for patients who seek esthetically acceptable orthodontic appliances. Monocrystalline ceramic brackets are more esthetically pleasing than polycrystalline brackets. In addition to the esthetic

Table 1. Descriptive statistics of shear bond strength (in MPa) for the two groups.

Base design	Minimum	Maximum	Mean	Standard deviation
Bead ball base	14.16	28.78	19.81	3.81
Mushroom shaped groove base	11.32	18.98	16.46	1.88

Table 2. Result of Independent sample t-test comparing SBS (MPa) of the two bracket types.

Type of bracket	Mean	Standard deviation	p-value	Mean difference	Standard error difference	95% Confidence Interval of the Difference	
						Lower	Upper
Bead ball base ceramic bracket	19.81	3.81	< 0.001*	3.35	0.85	1.64	5.06
Mushroom shaped groove bracket	16.46	1.88					

*p value < 0.05 indicates significant difference

appearance bond strength of the ceramic brackets is also important for its successful clinical use. Previous studies have shown that the bond strength of ceramic brackets are higher than that of the stainless steel metal brackets [8, 15, 19]. It has also been proven that brackets with various base designs are also different in their bond strength [13, 20].

Factors which influence the bond strength of the orthodontic brackets are the bracket base design, adhesive used, and the technique of bonding procedure employed such etching time, primer application and curing time. Since the present study was aimed to determine the shear bond strength of ceramic brackets with different base designs, all other variables such as the adhesive used and bonding technique were standardized. This was done to minimize the confounding bias in the study.

In the present study, shear bond strength (SBS) of 19.81 +/- 3.81MPa and 16.46 +/- 1.88MPa was obtained for ceramic brackets with bead ball base design and mushroom shaped groove base design respectively. Ansari et al compared shear bond strength of four groups of ceramic brackets and one group of metal brackets with various base designs, namely, adhesive precoated base, microcrystalline base, polymer mesh base, patented bead ball base and mechanical mesh base. He observed a mean SBS of 27.26MPa for microcrystalline base, 23.45MPa for bead ball base, 20.13MPa for adhesive precoated base, 17.54MPa for polymer mesh base and 17.5MPa for mechanical mesh base [8]. Samruajbenjakul and Kukiattrakoon reported SBS of 24.7MPa for bead base design, 21.3MPa for large round pits and 19.2MPa for irregular base design of ceramic brackets when bonded to glazed feldspathic porcelain [14]. Similar results were obtained by these authors when they bonded these brackets to aluminous and fluorapatite ceramics [15].

Even though the ceramic brackets with bead ball design showed higher shear bond strength, the SBS of mushroom shaped groove brackets are also clinically acceptable. Fracture site and enamel characteristics after debonding of these brackets must also be taken into consideration to assess their clinical advantage. Therefore studies comparing the post debonded enamel features for bead ball design and mushroom shaped groove base ceramic brackets are necessary.

Conclusion

- Shear bond strength of ceramic brackets with bead ball base design was significantly higher than that of the ceramic brackets with mushroom shaped groove base design.
- SBS of both the types of brackets were clinically acceptable

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