Comparative Evaluation of Shear Bond Strength of Zirconia Restorations cleansed various Cleansing Protocols Bonded with Two Different Resin Cements: An In vitro Study

Abstract

Context: Yttria partially stabilized tetragonal zirconia polycrystalline restorations have gained widespread use because of its enhanced strength and esthetics. During the try-in process, zirconia is likely to be contaminated with saliva. This contamination leads to a clear weakening of the bond between restorative material and cement. For this reason, zirconia surface should be cleaned before cementation. Hence, the purpose of this study is to compare the shear bond strength of zirconia restorations cleansed with various surface cleansing protocols bonded with two different resin cements. Materials and Methods: Eighty samples of zirconia discs were prepared in the dimensions 2.5 mm diameter and 4.5 mm thickness. They were divided into two groups of each forty samples based on luting cement used. Each group was further subdivided into four subgroups of each (n = 10): Group 1: uncontaminated zirconia blocks, Group 2: saliva-contaminated zirconia blocks and cleaned only with distilled water, Group 3: saliva-contaminated zirconia blocks treated with Ivoclean, and Group 4: saliva-contaminated zirconia blocks were air abraded. Eighty human maxillary premolars were then sectioned to expose dentin and were mounted on an acrylic block. A jig was fabricated to bond zirconia with the tooth using two self-adhesive resin cements. The samples were subjected to shear bond strength testing. The data were analyzed using one-way analysis of variance and Tukey’s honest significance difference test with a level of significance set at p < 0.05. Results: The mean shear bond strength values of Group 1 and 2 - subgroup B are 10.3 ± 0.4 and 9.80 ± 0.7 (saliva-contaminated zirconia, cleansed with distilled water only), respectively, were lowest among all test subgroups and were significantly less than mean values of subgroup C, Group 1 - 20.45 ± 0.6 and Group 2 - 20.75 ± 0.4 (Ivoclean group) and subgroup D, Group 1 - 20.90 ± 0.3 and Group 2 - 20.60 ± 0.5 (air abrasion group) (p < 0.05) for both test groups. Conclusions: In a clinical practice, a simple application of Ivoclean can be an effective alternative to air abrasion in removing salivary contaminants and improve resin-zirconia bonding.

Keywords: Ivoclean, salivary contaminants, self-adhesive resin cements, shear bond strength

Introduction

Yttria partially stabilized tetragonal zirconia polycrystalline restorations have gained widespread use in dentistry mainly because of its enhanced esthetics and increased fracture resistance.[1-3] Clinical success of the zirconia restorations depends on cementation process in providing good bond strength between the tooth and restoration. Although zirconia restorations can be luted with traditional luting cements, bonding of zirconia with adhesive resin cements can be beneficial in many ways such as providing increased retention and marginal adaptability.[4] However, bonding of resin to zirconia can be affected by a wide range of factors such as contamination of the restorative surface by saliva, the type of resin cements, and the bonding procedure employed during cementation. Most important of them is to provide a clean reactive restorative luting surface free of contaminants for successful cementation of the restoration. The restorative surface might get contaminated by saliva, blood, and silicone indicators during clinical try-in procedure which cannot be removed only by cleansing with water.[5-7] There are several recommended methods to remove these contaminants. The previous study by Klosa et al. has shown the use of water, alcohol, phosphoric acids, and sodium silicates as useful methods for removal of contaminants.
from restorative surface. However, the bond strength values obtained using these methods were lower than uncontaminated zirconia surfaces. Hence, a new introduced product Ivoclean was introduced (Ivoclar Vivadent AG, Schaan, Liechtenstein) with the hypothesis to be effective in removing salivary contaminants from the zirconia surface. However, there is very little scientific evidence evaluating the cleaning efficacy of Ivoclean on saliva-contaminated zirconia restorations.

Hence, the purpose of this in vitro study is to compare the shear bond strength of zirconia restorations cleansed with various surface cleansing protocols bonded with two different resin cements.

Materials and Methods

Specimen preparation

Institutional ethical committee clearance was obtained (684/IEC/2014) was obtained before the commencement of the study. Eighty noncarious, human maxillary first premolars extracted for orthodontic purpose were collected and stored in distilled water and ultrasonically cleansed using a scaler (Satelec Ultrasonics) to remove hard and soft tissue debris. The surfaces of the tooth were then evaluated for any defects or visible cracks under magnification (×2.5). Defective samples were then discarded. All the samples were stored in 0.1% thymol solution until testing for a maximum period of 6 months. The teeth were sectioned along the cemento-enamel junction using a diamond disc perpendicular to the long axis of the tooth. The buccal surfaces of the tooth were flattened with a diamond disc to expose sufficient amount of at least 10 mm² of dentin available for bonding procedures. All the specimens were then mounted on a clear acrylic block of diameter 7 mm and height 7.5 mm. The samples were then finished and polished with silicon grit carbide papers in the order (200, 400, and 600).

Sample preparation

Eighty samples of zirconia ceramic (Amann Girrbach AG, Germany) were fabricated in disc shape measuring 2.5 mm diameter and height 4.5 mm diameter according to manufacturer’s instructions. All the samples were finished and polished with a 600 grit silica carbide paper and air abraded with 50 μm aluminum oxide at 0.25 Mpa for 15 s at a distance of 10 mm². The samples were cleansed ultrasonically using isopropyl alcohol for 3 min, rinsed with water, and air-dried for another 15 s to remove any surface impurities. The samples were randomly allocated to one of the two test groups and further divided into four subgroups [Table 1].

Groups

Based on the resin cement used for the bonding procedure, the samples were divided into two groups of each (n = 40).

- Group 1 (n = 40) - samples bonded with self-adhesive resin cement RelyX U200 (3M ESPE) [Table 1].
- Group 2 (n = 40) - samples bonded with self-adhesive resin cement Multilink Speed (Ivoclar Vivadent) [Table 1].

Subgroups

Based on salivary contamination protocol, the subgroups:

- Subgroup A (n = 10) - No salivary contamination (control group)
- Subgroup B (n = 10) - Saliva-contaminated zirconia samples cleansed only with distilled water for 15 s and air-dried for 15 s
- Subgroup C (n = 10) - Saliva-contaminated zirconia samples, cleansed with a solution of Ivoclean for 20 s and rinsed with distilled water for 15 s and air-dried for 15 s
- Subgroup D (n = 10) - Saliva-contaminated zirconia samples were air abraded as mentioned above.

Saliva collection and contamination

For salivary contamination, all zirconia samples were immersed in human saliva for 1 min except for the control group. Fresh human saliva collection was done from one healthy nonalcoholic, nonsmoking individual who had refrained from eating and drinking 1 h before saliva collection. After contamination, the samples were rinsed with distilled water for 15 s and air-dried for 15 s.

Methodology

A jig [Figures 1 and 2] consisting of upper and lower metal plates of size 40 mm × 15 mm with machined screw fittings was fabricated. The lower plate has a trough of

| Product        | Manufacturer          | Lot number |
|----------------|-----------------------|------------|
| RelyX U200     | 3M ESPE, St. Paul, USA| 601637     |
| Multilink Speed| Ivoclar-Vivadent, Schaan, Liechtenstein | U52345 |
| Ivoclean       | Ivoclar-Vivadent, Schaan, Liechtenstein | U34552 |

Figure 1: Jig used for bonding
Figure 2: Bonded specimen with the jig

Table 2: Results

| Resin cements (groups)          | Group (1)   | Group (2)   |
|--------------------------------|-------------|-------------|
| Subgroup A                     | 25.00±0.8   | 24.45±0.5   |
| Subgroup B                     | 10.30±0.4   | 9.80±0.7    |
| Subgroup C                     | 20.45±0.6   | 20.75±0.4   |
| Subgroup D                     | 20.90±0.3   | 20.60±0.5   |

Shear bond strength values in megapascals. Group 1=RelyX U200, Group 2=Multilink Speed, Subgroup A=Control, Subgroup B=Distilled water, Subgroup C=Ivoclean, Subgroup D=Air abrasion

Discussion

Salivary contamination of the zirconia surface takes place during the clinical try-in procedure. Saliva contamination inhibits the stable bond formation of resin cement with zirconia.[2,11,12] Hence, the luting surface of the zirconium is contaminated by saliva, and the surface needs to be cleansed in an effective way. Saliva consists of proteins, enzymes, bacteria, and other organic materials which have phosphate groups such as phospholipids and phosphoproteins.[9] The previous study

Statistical analysis

The mean and standard deviation values were calculated from the samples for each group. The mean values were compared between different study groups using one-way analysis of variance followed by Tukey’s honest significance difference test. The level of significance was set at $P < 0.05$ carried out using SPSS software (SPSS 17.0 software, SPSS Inc, version 17.0, Chicago).

Results

Between the two test groups, Group 1 (RelyX U200) showed higher bond strength values than Group 2 (Multilink Speed) for all subgroups except subgroup C (Ivoclean group) ($P > 0.05$) with no statistical significance [Table 2]. Among the subgroups, the mean values of controls in both subgroups showed the maximum bond strength values which were significantly higher than all corresponding subgroups ($P < 0.05$).

The mean values of subgroup D (air abrasion group) were higher than mean values of subgroup C (Ivoclean) for Group 1 (RelyX U200), but there was no statistical significance ($P > 0.05$).

The mean values of subgroup B (distilled water) were lowest among all test subgroups and were significantly less than mean values of subgroup C (Ivoclean) and subgroup D (air abrasion) ($P < 0.05$) for both test groups.

Hence, the manufacturers and clinicians have come up with different approaches to increase the bond strength after salivary contamination. One such approach is the use of Ivoclean (Ivoclar Vivadent, Liechtenstein) solution.

Ivoclean consists of alkaline suspension of zirconium oxide and sodium hydroxide particles. The Ivoclean uses the principle that zirconium has a strong affinity for phosphate groups. According to manufacturer, due to the size and concentration of zirconium particles in Ivoclean, the phosphate contaminants are much likely to bond to Ivoclean than to the zirconium surface. Thereby Ivoclean absorbs phosphate contaminants such as a sponge leaving behind a clean zirconium surface for resin bonding.[16] There are also other methods to improve bond strength such as air abrasion. It is another useful method to treat saliva-contaminated zirconia surfaces.[2,11,12,15] However, in a clinical practice, it may not be feasible to use air
abrasion due to the complexity of zirconia restorations. Furthermore, the zirconia surfaces could additionally be contaminated by blood, silicone indicators which might also impair with resin-zirconia bonding. These were not evaluated in the current study and efficacy of different solutions on these contaminants needs to be evaluated.

Between the two resin cements used in the study, Multilink Speed (Ivoclar Vivadent) showed lower bond strength values than RelyX U200 (3M ESPE) though it was not statistically significant. According to the manufacturer, Multilink speed consists of long chain methacrylate with a phosphoric acid group. The phosphoric acid group enables a stable chemical bond to zirconium oxide surface; the principle that zirconium has affinity for phosphate group is being used. RelyX U200 also utilizes the same composition of Multilink Speed having phosphoric acid-based methacrylate monomer forming a stable chemical bond with the dentin. However, the small difference in bond strength values may be attributed to the fillers and/or concentration of the phosphate group. Both the resin cements used in this study can be used both in self-cure mode and light cure mode. In this study, it was used in self-cure mode as light penetration through zirconia is impaired.

Both resin cements used in the study contained 10-MDP monomer which is essential to establish a stable chemical bond between the dentin and the zirconia surface. The luting cement penetrates the smear layer which gets incorporated into the polymer network as the cement sets, thereby sealing the dentinal tubules. The advantage of using self-adhesive resin cement is that it reduces the number of pretreatment steps and saves the time of both patient and dentist. According to Radovic et al., self-adhesive resin cements showed comparable bond strength values with light-cured resin cements.

The jig used in this study for bonding procedure is in accordance with the methodology used by Usman and Nisha. The jig was fabricated so as to provide uniform film thickness of the resin cements in all the samples and to standardize the bonding procedures. The previous study by Dalby et al. has also recommended the use of finger pressure for bonding samples to the tooth as it mimics the clinical scenario. However, this may affect the bond strength results and was not used in the current study. Mylar strip was used as it provides uniform film thickness of 40 μm which is equivalent to cement spacer thickness. Another study by Ozyoney et al. used the application of static load of 5 kg until the cement hardened which is also an acceptable method.

Our study results showed the maximum bond strength values for control group and least bond strength values for salivary contaminated, cleansed only with water. This finding is in accordance with the previous study by Yang et al. that salivary contamination reduces bond strength values. The current study results showed no statistical significance between Ivoclean-treated subgroup and air abrasion subgroups. This suggests that a simple application of Ivoclean could be an effective alternative to air abrasion.

**Conclusion**

Within the limitations of the study, it can be concluded that

1. Salivary contamination significantly reduces resin shear bond strength to zirconia
2. In a clinical practice, a simple application of Ivoclean can be an effective alternative to air abrasion in removing salivary contaminants
3. Both resin cements used in the study showed clinically acceptable bond strength values with no statistical difference.

However, long-term clinical studies are required to evaluate the efficacy of different cleaning solutions.

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**Conflicts of interest**

There are no conflicts of interest.

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