Original Article

A Comparative Evaluation of Shear Bond Strength of Creation Ceramic Veneer to Metal and Zirconia Cores

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ABSTRACT

Background and Aim: High chipping rates of the veneering porcelain of zirconia ceramic restorations have been reported in clinical studies. Thus, the shear bond strength (SBS) between the zirconia core and veneering porcelain requires investigation.**Ma Materials and Methods**: In this in-vitro study, at first, using a computer-aided design/computer-aided manufacturing (CAD/CAM) machine, 16 zirconia cores of Kerox were provided. Using the casting method, 16 base metal cores were provided. All the cores were veneered with the Creation ceramic veneer. Afterwards, the samples were put under a static force in the universal testing machine at a crosshead speed of 1 mm/minute until fracture. T-test was used to analyze the data.

Result: IThe mean SBS for the base metal and zirconia groups was 27±7.43 and 27.75±8.75 Megapascal (MPa), respectively (P=0.812).

Conclusion: There was no significant difference between the metal-ceramic and zirconia ceramic groups in SBS so that the Creation ceramic veneer may solve the problems related to the bond of all-ceramics to ceramic veneers.

Keywords: Zirconia, Base Metal, Veneer Porcelain, Shear Bond Strength.

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Introduction:

More than half a century has passed since metal-ceramic restorations were introduced to dentistry. During these years, extensive use of fixed prostheses has made this kind of restoration (fixed partial denture; FPD) a reliable choice in dental treatment.(1,2) As this treatment led to esthetic dentistry and the introduction of full ceramic materials with characteristics such as ideal esthetics, biocompatibility, and long-term stability, the demand for this kind of restoration has increased.(3) By introducing tetragonal zirconia polycrystal (TZP) as a restoration base, the production of multi-unit restorations with maximum reliability and success has become possible.(4) Zirconia has high flexural strength (900-1000 MPa), fracture toughness (9-10 MPa), and fracture resistance of more than 2000 MPa when used in FPDs. Nevertheless, one of the faults of this restoration is the weak ceramic veneer bond to zirconia core, which causes ceramic chipping.(5-9)Many clinical studies have evaluated zirconia ceramic restorations. The high stability of zirconia frameworks has been reported; a five-year period with the degree of success more than 97.8% has been recorded.

Nonetheless, ceramic veneer chipping and fracture with a rather high rate (6%-30%) in zirconia posterior restorations with a ceramic base within a 5-10-year period have been observed [10-15] while articles about metal base restorations have not shown any failure in the ceramic veneer or few fractures has been detected (2.7%-5.5%) in a 10-15-year period. [16,17]

Various factors, such as residual stress because of the difference in the thermal expansion coefficient, structure deficiency, and defects at the surface between core and veneer, wetting property, and veneer volumetric shrinkage, influence ceramic-zirconia bond.[18] Also, factors such as the type of alloy, special techniques, thermocycling, the thickness of the opaque layer, and type of metal and adhesives influence the ceramic and metal bond.[19-22] The bond fracture may depend on each of these factors. Saito et al stated that ceramic and zirconia bond is comparable with the bond to metal and it depends on the thickness of the porcelain.[23] Choi et al compared zirconia and metal bond and reported a significant difference between these two bonds.[24] In other studies, one of the effective factors in the bond between zirconia and veneer ceramic has been introduced. (25,26) In another research, Abrisham et al evaluated the shear bond strength (SBS) of porcelain to base metal compared to zirconia core. This research concluded that there was no significant difference between the two groups of porcelain-fused-to-metal (PFM) and PFZ in SBS.[27]

Quinn et al compared the edge chipping resistance of PFM and veneered zirconia specimens. They concluded that the tested PFM and zirconia specimens had similar resistance to edge chipping, in spite of very different substrate properties.[28]

Many zirconia core companies suggest special veneer ceramics for a better bond with zirconia core. The Creation veneer ceramic has been known all over the world for 25 years. It has been shown that this product contains a dense porous structure for pure layering without impact and with maximum stability. Pure feldspathic Potash with pure lucid microcrystals in this product cause light breakdown and natural shine. Its high elasticity is because of high and permanent flexibility. Considering different results taken from previous research, this research aimed to compare the SBS of zirconia core and metal with Creation veneer ceramic to check veneer compatibility with the available core.

Materials and Methods:

This in-vitro experimental study involved zirconia cores built up using a computer-aided design/computer-aided manufacturing (CAD/CAM) system and base metal cores built using a casting system.

First, 16 samples of zirconia disks (Kerox, Hungary; 7mm in diameter and 2mm in height) were designed and prepared by the CAD/CAM system (Roland, Japan). Then, pre-sintering was done on zirconia samples, and the samples were sintered according to the manufacturer's instructions (1500°C for 6 hours). In addition, 16 metal disk samples (super bond, nonprecious, and beryllium free, USA) were built using a casting system (Ducatron casting machine, France; 7mm in diameter and 2mm in height). Samples were sandblasted to improve the bond.[29] Afterwards, degassing and oxidation were carried out at 1050°C and the samples were sandblasted with 110µm alumina oxide. Then, the thickness of the cores was measured using a caliper. The samples were divided into two groups in which the Creation porcelain (Creation, Austria) was randomly used. In the zirconia group, before placing the porcelain, a liner was placed on the zirconia surface, and in the metal group, an opaque interface was placed. The Creation ceramic veneer should be veneered with identical thickness on the zirconia core and metal base. To standardize the thickness, plexiglass was used. Porcelain was placed by an experienced technician in a way that there was a 5mm-diameter and 3mm-thick zirconia on the cores. The samples were fired (920°C and one-minute holding time for metal base samples and 910°C and one-minute holding time for zirconia pattern; YOJIN, France), and after firing, the excess was removed. Then, to be ensured of the exact area of each sample, the diameter of each sample in three different sides was measured using a caliper. The samples were mounted in self-curing acrylic resin, and the SBS was examined using a universal testing machine (Zwick, Germany).

A fixed crosshead speed of 1 mm/minute at a 90-degree angle was selected, and the head of the crosshead was located as close as possible to the contact surface in a way that the force is in contact with the ceramic only. The mean SBS was measured and recorded and used for comparison of mean SBS and maximum entered force in the two groups. Then, the bond was compared between the two groups using t-test.

Results

The research was done on 32 samples including 16 samples with metal core and 16 samples with zirconia core (Figures 1 and 2). The mean SBS of the samples is presented in Table 1. In the metal core group, the mean SBS was 27±7.43 MPa, and the coefficient of variation (CV) was 27.

In the zirconia core group, the mean SBS was 27.75±8.75 MPa, and the CV was 31. Overall, the mean SBS of zirconia was 0.75 MPa or 2.8% more than that of metal core, and t-test showed that this difference in the SBS was not significant (P=0.812).

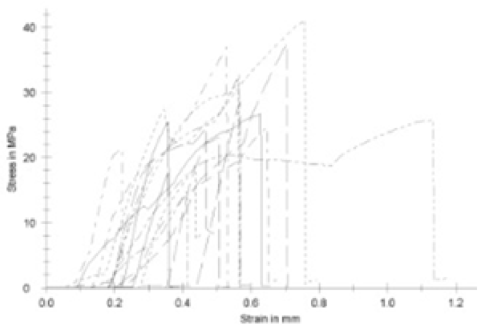

Figure 1. Stress/strain of metal samples

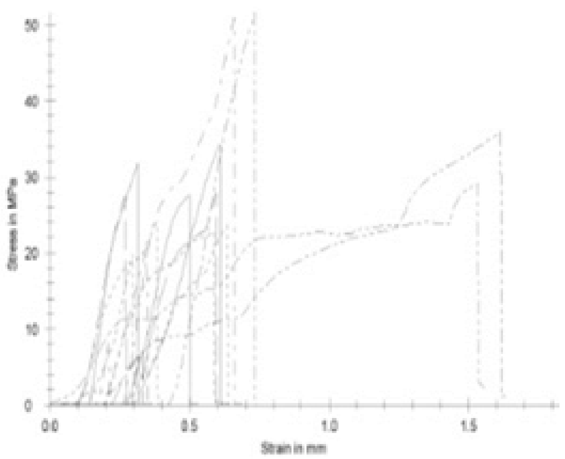

Figure 2. Stress/strain of zirconia samples

Table 1. Distribution of samples according to shear bond strength (SBS) and core type Core type SBS CV

Core type	SBS	CV
Metal	27±7.43	27
Zirconia	27.75±8.75	31

CV=Coefficient of variation

Discussion

For more than 40 years, ceramic-metal restorations have been used as a standard restoration in dentistry. The problem of this restoration is mismatching of color with the patients' teeth. In the early nineteenth century, the problem related to aesthetics was resolved by introducing zirconia, but there are also some concerns about the bonding of these materials with ceramic. According to previous studies, the type of ceramic veneer affects the zirconia bond.[30] Therefore, in this research, we studied a new veneer ceramic named Creation. According to the results of the research, the difference in the SBS of zirconia and metal with Creation ceramic veneer was not significant (P=0.812).

In the present research, the SBS measure of built samples after porcelain placement and the effect of core type were evaluated. Many studies have been performed on the SBS measure and the effect of different factors on it but the role of the construction process by the CAD/CAM machine and the new veneer ceramic i.e. Creation has been researched limitedly.

In the present research, we used zirconia disks and metal with the recommended porcelain powder manufactured by the Creation Company, and to standardize the sample construction conditions, the samples were prepared by a skilled technician in a laboratory simultaneously to mimic the clinical conditions.

Using a compressive force for the failure of the samples without regarding the fatigue process was one of the limitations in this study. We could not rebuild all the forces applied to restorations in the clinic.

While physiologic cycling loading is applied to restorations during chewing, the materials get fatigued. In this research, one aspect of force (vertical) was investigated.[31]

One of the attempts for improving the contact surface between core and veneer is the use of surface liners on zirconium oxide before veneering.[32] In this research, Creation ZI-CT was used on the cores.

The durability of ceramic-metal restoration depends on an acceptable bonding between ceramic and metal, which is initially provided by the oxide layer.[33] If the oxide layer is absent or thin, it will be omitted during sintering, which results in a weak bond; however, a thick oxide layer should also be avoided because it would weaken the tensile strength.[19] In this research, similar to the study by Choi et al, initial oxidation was carried out on the metal base.

In a study by Aboushelib et al, pressable porcelain is used instead of a layer.[30] The difference in statistical data in different studies depends on the combination of strength and coefficient of thermal expansion, cooking shrinkage, porcelain-cooking cycle, particle size, core thickness, shape, mixture, density, and hardness.

An ideal veneer ceramic debonding from metal is considered for metal-ceramic restorations in forces more than 25 MPa.[34] In this study, the mean SBS was 27±43.7 MPa, which is an acceptable result. Similar to the study by Saito et al, there was no significant difference in SBS between zirconia core and metal.

Dundar et al [35] reported that SBS rages from 41 to 23 MPa, and Al-Dohan et al [36] reported SBS in the range of 22-31 MPa. Choi et al (24) reported SBS in the range of 22-43 MPa for full ceramic systems. In this research, the SBS for Creation ceramic veneer to zirconia was in the range of 20-35MPa, which confirmed the findings of previous studies.

In this study, contrary to the study by Choi et al, [24] there was no significant difference between zirconia and metal groups; this difference can be attributed to several factors such as type of study, methodology, the skill of the technician, and structural difference of materials. The porcelain bond mechanism to zirconia is not exactly clear. However, the difference in coefficient of thermal expansion is an effective factor, and since zirconia thermal conduction is less than that of metal, cooling process and thermal transformation are done later, and the stress from thermal changes remains, leading to failure. The close coefficient of thermal expansion of porcelain to zirconia provides a better bond.

Guazzato et al and Saito et al stated that more difference in the coefficient of thermal expansion of core and veneer creates a layer with higher stress at the interface of the two materials. [23,37] In this research, the difference in the coefficient of thermal expansion of zirconia core and Creation veneer ceramic was a little out of the ideal range.

The present study and the study by Abrisham et al showed no significant difference in SBS between Creation and feldspathic ceramic for veneering metal and zirconia cores. [27]

In general, it is shown that many factors affect the SBS of core-ceramic. Factors like the type of core, core thickness, ceramic type, ceramic thickness, using liner before porcelain, core sandblasting, metal-core oxidation, low difference in thermal expansion coefficient between core and veneer, are more effective on SBS improvement.

Finally, this study was done in vitro, and factors such as anatomical forms of restorations, temperature, environment humidity, occlusive force direction, and veneer porcelain thickness are different from the clinical conditions and need complementary research.

Conclusion

There was no significant difference between the metal-ceramic and zirconia ceramic groups in SBS so that the Creation ceramic veneer may solve the problems related to the bond of all-ceramics to ceramic veneers.

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