Journal section: Clinical Dentistry
Publication Types: Research

doi:10.4317/medoral.15.e919

Bond strength evaluation of the veneering-core Ceramics bonds

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Received: 15/09/2009
Accepted: 21/02/2010

López-Mollá MV, Martínez-González MA, Mañes-Ferrer JF, Amigó-Borrás V, Bouazza-Juanes K. Bond strength evaluation of the veneering-core ceramics bonds. Med Oral Patol Oral Cir Bucal. 2010 Nov 1;15 (6):e919-23.
http://www.medicinaoral.com/medoralfree01/v15i6/medoralv15i6p919.pdf

Article Number: 3178 http://www.medicinaoral.com/

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Abstract

Objective: The purpose of this study was to determine whether the bond of veneering porcelain to a ceramic core in bilayered ceramics was similar to that of the metal ceramic control of well known behaviour.
Study design: Six groups of nine specimens each were fabricated, whose dimensions were 15 mm long and 8 mm in diameter at the core, and 2 mm long and 8 mm in diameter for the veneer. The groups were GR. 1 (control group): CrNi alloy/d.SIGN (Ivoclar), GR. 2: IPS e.maxPress/IPS e.maxCeram (Ivoclar), GR. 3: IPS e.maxZirCad/IPS e.maxZirPress (Ivoclar), GR. 4: IPS e.maxZirCad/IPS e.maxCeram (Ivoclar), GR. 5: Lava Frame (3M ESPE)/Lava Ceram (3M ESPE) and GR. 6: Lava Frame (3M ESPE)/IPS e.maxCeram (Ivoclar).
A shear strength test was used in all samples with a universal testing machine. The chosen crosshead speed was of 0.50 mm/min. The obtained results were analyzed using a one way analysis of variance test (ANOVA) to determine whether significant differences existed between the groups ($p<0.05$). A Student Newman-Keuls multiple comparisons test was used.
Results: GR. 1: 13.45 MPa, GR. 2: 24.20 MPa, GR. 3: 12.70 MPa, GR. 4: 7.86 MPa, GR. 5: 10.20 Mpa and GR. 6: 4.62 Mpa.
Conclusions: The bond strength of group 1 (control) was similar to groups 3 and 5. Group 2, whose core and veneer are both porcelains with a similar chemical composition, with silica as their main component, achieved the best adhesive results between both porcelains. The technique on zirconia cores that showed the higher results was the pressed technique. The lowest results were for the group using porcelains from different manufacturers.

Key words: *Ceramic, zirconia, shear test, bond strength.*

Introduction

In modern dentistry, the use of ceramic materials joined to a metal as a way of increasing their resistance is widely spread, as they have given good results over the years, and offer great reliability (1,2). However in the past few years, the great aesthetic demand and the necessity of using more biocompatible materials have forced clinicians and technicians to look for metal free prosthodontic restorations that give a certain security in regard to their hardness (1,3).

The reinforced all ceramic crowns consist of a high resistance porcelain core instead of metal, and dentinal and incisal porcelain veneer (4).

To assure the good resistance of these porcelain cores, new core ceramic materials have been progressively introduced. Beside the lithium disilicate, we have also available aluminium oxide porcelains and more recently the zirconia that has very good mechanical properties (5).

We have to consider that the cores, as well as the veneers, are different in behaviour regarding both their elasticity module and different coefficient of thermal expansion (CTE), so imply the appearance of a residual stress between them (6).

Bond metal and porcelain mechanisms have been widely studied (7) but little is known about the microstructure, strength land joint mechanisms among different core and veneer porcelains and their mechanical structures (8).

Zirconia, a material widely developed in the past few years due to its great resistance to substitute the metal in bridge and crowns, can work in posterior sectors. It is a material without glass phase that has nothing to do with the aesthetic ceramics that covers it, and with different mechanical properties. Therefore the nature of the bond between both structures may not be clear (8,9).

• Objectives:

The aim of the study was to evaluate the shear bond strength of different core/veneering ceramic systems compared to the well-known metal/ceramic frameworks. In particular, the null hypothesis tested is that there is no difference in terms of bond strength between different cores.

Other purposes of the study were to specifically analyse the resistance of the bond between different zirconia cores ceramic and silica veneers for all-ceramic restorations; to determine whether the resistance of the bond between the zirconia core and the aesthetic ceramic covering it varied depending on the technique (layer/pressed) used to bond them; and to determine whether the bond varied if a different aesthetic ceramic was used to cover the zirconia cores, other than the one recommended by the manufacturer.

Material and Methods

Fifty four specimens were fabricated, divided into six groups of nine samples each. All specimens were made following the same pattern (Fig. 1). It consisted of cylinders of 15 mm long and 8 mm in diameter for the core and 2 mm long and 8 mm in diameter for the veneer.

The control group was made based on a metallic alloy covered with conventional porcelain, while the rest of groups were made with different core ceramics and their silica veneers.

• Group 1: was composed of specimens whose core consisted of a chromo nickel (Rexilium®V, Pentron ® Alloys) and the veneer was a layers technique silica porcelain, IPS d.SIGN ceramic (Ivoclar AG,Schaan, Lietchtenstein). This was the control group due to its well known behaviour.

• Group 2: was formed by silica core and veneer, with pressed lithium disilicate core, IPS e.maxPress (Ivoclar), and a fluorapatite veneer by layers technique, IPS e.maxCeram (Ivoclar).

The rest of the groups had as cores the machined zirconia ceramic.

• Group 3: was made of a zirconia core machined by the CAD/CAM technique, IPS e.maxZirCad (Ivoclar) and a fluorapatite veneer by pressed technique, IPS e.max ZirPress (Ivoclar). Once the core was obtained, a thin layer of fluorapatite ceramic called "zirliner" (Ivoclar) or bonding agent was applied on the core top to fabricate the veneer, improving the bond between both.

• Group 4: was also formed by IPS e.maxZirCad (Ivoclar) core by CAD/CAM technique. This time the fluorapatite veneer used the layers technique, IPS e.maxCeram (Ivoclar). Here, zirliner was also used as bonding agent.

• Group 5: was composed of a machined zirconia core obtained by the CAD/CAM technique, Lava Frame (3M, ESPE) and a feldspathic veneer by layers technique, Lava Ceram (3M, ESPE). After obtaining the core a thin layer of feldspathic ceramic called ¨modificator structures¨ was applied, this is used to moisten the core surface for the veneer adhesion, like the zirliner mentioned before.

Fig. 1. Specimens group 3.

• Group 6: was formed by Lava Frame (3M ESPE) core as in group 5, but instead of using its Lava ceramic veneer we used fluorapatite porcelain from another manufacturer, IPS e.maxCeram (Ivoclar) by layers technique. We used zirliner from Ivoclar manufacturer as bonding agent between the core and the veneer.

In (Table 1) the analyzed groups are schematically displayed showing their composition and fabrication techniques.

So that we could test our samples, we had to insert them in a specific accessory. Therefore we supported them in copper rings and die stone. In this way they were exposed one millimetre from the core. Once the samples were inserted in their accessories the test was carried out using a shear test for that, a universal testing machine was used (4204 model, Instron Corp., Canton, MA) (Fig. 2).

Table 1. Groups composition and manufacture techniques.

SPECÍMENS	CORE	VENEER
Group 1.(control)	Metallic alloy	IPS d.SIGN
Composition	Cr-Ni	apatite-leucite
Elaboration technique	melted	layers
Group 2.	IPS e.max Press	IPS e.max Ceram
Composition	Lithium disilicate	fluorapatite
Elaboration technique	pressed	layers
Group 3.	IPS e.max ZirCad	IPS e.max ZirPress
Composition	zirconia	fluorapatite
Elaboration technique	CAD-CAM	pressed
Group 4.	IPS e.max ZirCad	IPS e.max Ceram
Composition	zirconia	fluorapatite
Elaboration technique	CAD-CAM	layers
Group 5.	Lava Frame	Lava Ceram
Composition	zirconia	feldspathic
Elaboration technique	CAD-CAM	layers
Group 6.	Lava Frame	IPS e.max Ceram
Composition	zirconia	fluorapatite
Elaboration technique	CAD-CAM	layers

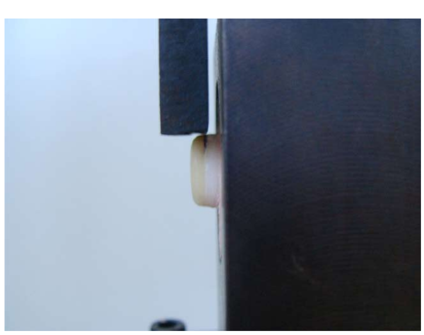

Fig. 2. Shear strength test. Lateral vision.

The samples were placed inside the device designed to receive the specimens moulded in the coppering. The pointer applying the charge, with a rectangular shape, was situated as near as possible to the core/veneer interphase, where a vertical and continuous force was exerted.

The crosshead speed chosen was 0.5 mm/min. until sample failure. The machine stopped when the sample failure occurred.

The last necessary load value until sample failure was registered by a compatible computer connected to the Instron ® machine. The obtained values in Newton were converted into MPa stress values through the following formula:

$$\text{Shear stress (MPa)} = \frac{\text{load (N)}}{\text{area (mm}^2\text{)}}$$

The obtained results were statistically studied by the SPSS 12.0 Program (SPSS Inc. Chicago Illinois, USA program).

In the first place a descriptive analysis was done of the obtained results for the dependent variable “resistance to shear strength”. In order to evaluate the normal and equal distribution of the data, the Kolmogorov-Smirnof and the Levene´s tests were respectively performed. As data were normally distributed, a one-way ANOVA was used. The Student-Newman Keuls test was used for the post-hoc comparisons. The level of significance was set up $p<0.05$.

Results

Mean shear strength values and standard deviation values of the tested groups are reported in (Table 2).

The multiple comparison test showed that for the chosen value:

• Group 6 (Lava Frame/IPS e.maxCeram) and group 4 (IPS e.maxZirCad/IPS e.maxCeram) didn’t show significant differences between them (α = 0.058) but for group 6 with the rest of the groups.

• Group 4 (IPS e.maxZirCad/IPS e.maxCeram) and group 5 (Lava Frame/Lava Ceram) didn’t show either statistically significant differences between them (α = 0.166). In relation to group 6 their values were somewhat higher.

• Group 4 (IPS e.maxZirCad/IPS e.maxCeram) and group 3 (IPS e.max ZirCad/IPS e.maxZirPress) showed statistically significant differences between them. The manufacturer is the same for both porcelains but the veneering porcelain has a different behaviour depending on the applied technique, either by layers or pressed. The pressed technique had the highest results.

• Group 5, 3 and 1 (Lava Frame/Lava Ceram, IPS e.maxZirCad/IPS e.maxZirPress and CrNi/IPS d.SIGN) didn’t show statistically significant differences between them (α = 0.136), with similar values of shear strength resistance. The highest values in relation to group 3 and 5 were for group 1. Therefore group 5 and 3 experienced behaviour more similar to the control group. Groups 3 and 1 did shown statistically significant differences with respect to the rest of groups

• Group 2 (IPS e.maxPress/IPS e.maxCeram) offered the greatest shear strength resistance, presenting significant differences with the rest of groups.

In (Table 2) are represented with the same letter those groups which didn't show statistically significant differences between them.

Discusion

Numerous studies (2,10) are found in literature which analyze different materials shear bond with their respective veneers. According to Al-Doham et al. (4) the shear test is the most adequate for the study of porcelain bonds. Aboushelib et al. (10), Dundar et al. (11), Anusavice et al. (12) affirm that the test results are influenced by the design of the specimens, therefore it is difficult to compare different studies at the same time.

In relation to the results, the metal ceramic control group obtained similar behaviours with regard to zirconia groups, being the metal ceramic group the one that got slightly higher results.

Al-Doham et al. (4) also achieved similar results between zirconia core groups and metal ceramic ones, and like our results, it was the metal ceramic control group the one that got slightly higher values in regard to zirconia groups; not finding statistically significant differences. Guess et al. (13) didn't find statistically significant differences between metal ceramic control group and the zirconia groups with veneers by layers technique.

Different authors (4) affirm that the pressed lithium disilicate porcelains and their veneer porcelains are those that achieved the highest shear strength results as in our results. No significant differences were found in regard to zirconia and control group. Our results showed significant differences among the lithium disilicate group and zirconia groups coinciding with Aboushelib et al. (10).Being this, the most logical finding if we consider that silicate ceramics in the core and in the veneer have a very similar chemical composition.

One of the established purposes of this study was to valuate the shear strength difference between the zirconia cores and their veneer in relation to the veneer technique. The obtained results gave slightly higher results for the pressed veneers on zirconia in regard to those applied by layers technique, with statistically significant differences between both groups. On the contrary Tsalouchou et al. (14) didn't find statistically significant differences between the zirconia specimens with veneer by the layers technique or by the pressed one. The one that obtained the highest results was the pressed technique because the veneer being injected by pressure on the core had got a closer contact between veneer and core, with the least amount of pores incorporated, therefore with the least initial cracking points.

Isgro et al. (15) concluded that the all ceramic crowns final resistance depended on the preparation of the ceramic veneer surface and that there was no difference in the resistance between all ceramics with or without veneer. On the contrary, Tinschert et al. (5) affirmed in their study that the restorations whose cores were covered by veneers porcelain offered a better resistance.

In many of the tested samples, the presence of porosity in the porcelain veneer surface acted as the place where the sample failure began. The porosity could be the result of the air trap during the mixture or condensation of the little particles or by the gases created during the sintering. Special importance should be given to the crack origin in these specimens. The load directs the crack propagation due to the residual stress by the different CTE between core and veneer. The frequent chipping found in the clinic studies can be the result of surface imperfections in the veneer (16).

Conclusions

The conclusions obtained from the in vitro study carried out for the analysis of the join resistance between both materials were the followings.

The zirconia cores and their respective silica veneers showed a weak union. The shear strength values they had were inferior to those obtained by metal ceramic restorations.

The best adhesive results were found in the group formed by all silica samples with lithium disilicate cores and fluorapatite veneer. This was due to the fact that both the core and the veneer showed chemical bond as they are porcelains with a similar composition.

The veneer technique for zirconia cores which got the highest values in the shear strength test was the pressed technique.

When using veneering porcelains for zirconia cores that weren't recommended by the manufacturer, the bond between them were the weakest.

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Acknowledgements
The authors would like to thank Ivoclar- Vivadent and Lava (3M ESPE) for the kind donation of materials. We would like to acknowledge the fabrication of the specimens to dental techniques R. López and V. Fornas.