Eur. J. Prosthodont. Rest. Dent., Vol.16, No. 1, pp 35-38
Printed in Great Britain

Bond Strength of Luting Materials to Ceramic Crowns after Different Surface Treatments.

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Abstract - *The aim of present study was to evaluate the effect of different pre-treatments of alumina and zirconia copings on the bond strength of different luting materials. Pull out tests was performed on 60 alumina and 80 zirconia copings. Randomly selected, copings were divided in groups of; i) un-treated alumina and zirconia copings, (n=20) ii) alumina and zirconia copings sandblasted with 50 or 110 µm alumina particles respectively (n=20), iii) zirconia copings treated with monolayer of glass pearls fused to the inner surface (n=20) , iv) zirconia copings treated with silanized glass pearls (n=10). Zinc phosphate, Panavia 21 and VarioLink II were used for cementation. Pull out tests were done in an Instron universal testing machine with a speed of 0.5 mm/min and fracture loads was measured in N. Untreated zirconia copings cemented with zinc phosphate showed significantly higher bond strength values compared to those with sandblasted surfaces. No difference was seen between untreated alumina copings and those with sandblasted surfaces. Sandblasting decreased bond strength of zirconia and alumina copings. Glass pearls increased bond strength of zirconia copings, which was even better after silanization. Variolink II in combination with alumina gave significantly lower bond strength.*

KEY WORDS: dental ceramics; alumina; zirconia; luting materials; bonding

INTRODUCTION

The development of alumina and zirconia for all-ceramic fixed prosthodontics has made it possible to make even extensive ceramic reconstructions. In recent time the interest has focused on zirconia due to its specific material properties. The passive surface with low energy demands a safe technique for cementation to tooth surfaces. It is well known that adhesive cementation increases the strength of ceramics and the resistance to fracture and also creates a firm bond of the reconstruction to teeth [1,2] . The retention of crowns to teeth depends on convergence angle and the height of the preparation. Several cements are available on the market and the choice is not easy for every material. A number of techniques have been reported to improve the resin - ceramic bonding.

Theoretically, air abrasion could be used to increase the mechanical retention of all types of cements. Silanes have some effects of feldspatic ceramics where a chemical bond is established between the ceramic surface and the resin luting material. This is not possible with alumina and zirconia since silanes are attached to silicon structures and alumina and zirconia contains no silicates [3]. Hydrofluoric acid pre-treatment for glass containing ceramics had no effect on ceramic coping materials [4]. In clinical practice conventional cementation of all-ceramic crowns could sometimes be under consideration [5]. Results from studies of adhesively luted coping materials differ, for example the bond strength of stored and thermo-cycled alumina restorations has found to decrease after six months [6,7]. Other studies have reported that silanization before bonding has either increased or decreased bond strength [3,8]. However, sandblasting with or without etching has a positive affect on bond strength to alumina [9,10].

Bond strength of resin materials to zirconia seems to show the same results as for alumina and thermo cycling reduces the initial bond strength values [11]. One report claimed that silanization was more effective than sandblasting while another showed the opposite [12,13]. One study showed that tribochemically coating with silica gives slightly higher bond strength compared to only sandblasting, however, the opposite results have been shown in other studies [14,15]. Especially zirconat coupling agents tested together with resin cements seems to have a positive effect on the bonding [16].

Most studies are based on shear strength tests, which are a fairly easy handling standard test. In order to better simulate clinical conditions bond strength could be tested using a standard hard core material bonded to a defined tooth preparation and then subjected to load until bond failure.

The aim of the present work was to study the effect of different pre-treatments of alumina and zirconia copings on the bond strength of different luting materials and to analyse the effect of sandblasting on the surface texture of these materials and its subsequent effect on bond strength.

METHODS AND MATERIALS

Twenty steel models were produced in a lathe machine making conical chamfer preparations with sandblasted rough surfaces and a mantel area of 112 mm^2 and a convergence angle of 15° (Figure 1). Pull out tests were performed with 60 aluminium oxide and 80 zirconium

* DDS Phd
† DDS

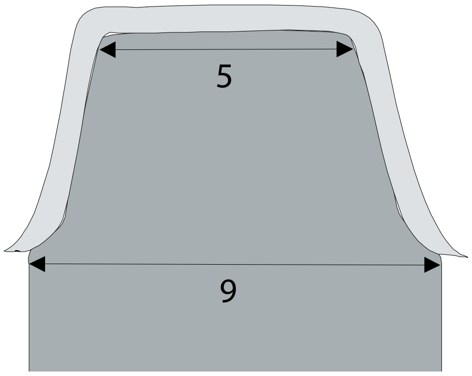

Figure 1. *Ceramic coping cemented on steel preparation (mm).*

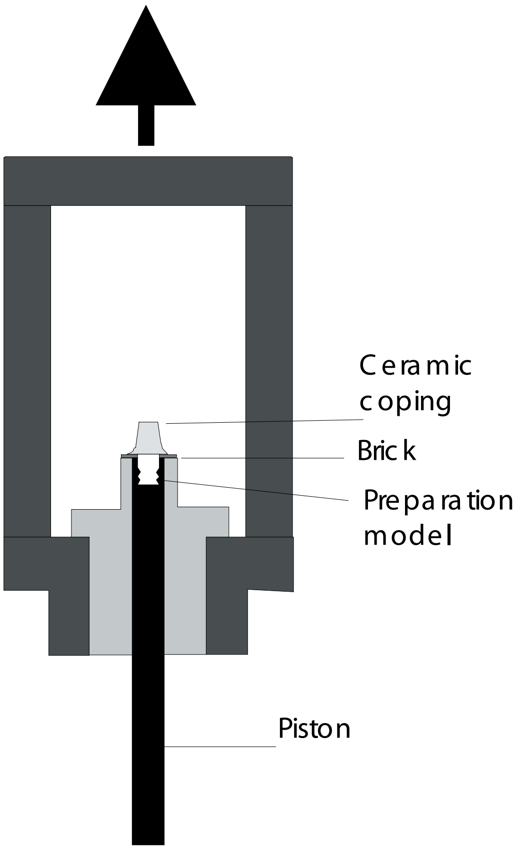

Figure 2. *Testing jig for pull out tests in an universal testing machine.The brick press the copings off the preparation as the piston is fixed.*

oxide copings produced according to the Procera milling technique where the steel models were scanned with a contact probe instrument and the copings were drilled out of presintered alumina and zirconia blocs.

- Twenty, randomly selected, zirconia and alumina copings were sandblasted for 15 s with 50 µm aluminium oxide.
- Twenty zirconia and 20 alumina copings were sandblasted for 15 s with 110 µm aluminium oxide.
- Ten zirconia specimens were treated with a monolayer of glass pearls fused to the inner surface of the copings at 720 C without vacuum.
- Ten of the zirconia copings were treated with a monolayer of glass pearls and additionally silanized.
- Twenty zirconia and alumina copings respectively were left untreated.

The sandblasting was done at 500 kPa with a distance of 10 mm between the inner surfaces of the copings and the blasting tip. The surface texture was measured in Ra µm with a surface roughness tester (probe r = 5 µm, range Ra 0.01 - 75 µm and test length 1.25 mm). The measurements were made inside the copings at four sites. All copings were washed in an ultrasonic bath for 5 minutes and carefully dried with air before cementation. Three different cements were used, zinc phosphate, Panavia 21 and VarioLink II. When Panavia 21 was used the inner surfaces of the copings were treated with Panavia 21/Alloy primer and for VarioLink II with Monobond in the same way.

The copings were cemented with a load of 12 kg for 10 minutes in 37C. After 20 minutes in air and room temperature the specimens were placed in water 37 C for 3 days. Excess of the cement was carefully removed in a rotation bench with a diamond disc. Pull out tests was done in an Instron 1121 universal testing machine with a speed of 0.5 mm/min and the fracture load was measured in N (Figure 2). The test results were statistically analysed using ANOVA Tukey multiple comparison tests.

RESULTS

All fractures occurred in contact area between the ceramic and the resin cement and no traces of cement were found on the ceramic surfaces after inspection. The surface roughness of the inside of the copings is shown in Table 1. Sandblasting reduced surface rougness and gave significant lower bond strength values ($p<0.001$) compared to untreated zirconia surfaces after cementation with zinc phosphate cement. For alumina copings there were no differences between untreated and sandblasted surfaces (Table 2).

Sandblasted alumina and zirconia copings seated with Panavia 21 showed a tendency but not significantly lower bond strength values compared to untreated zirconia copings. When resin cement was used untreated zirconia copings showed significantly higher retention values ($p<0.05$) compared to untreated alumina copings. Glass pearls attached to zirconia copings gave significantly higher retention values compared to untreated zirconia copings ($p<0.001$). After silanization of the glass pearls the retention values increased further ($p<0.001$) (Table 3). Panavia 21 and Variolink II combined with untreated zirconia copings demonstrated no differences in retention. However, in combination with alumina significantly lower bond strength values ($p<0.001$) were found for Variolink II compared to Panavia 21 (Table 4).

Copings treated with glass pearls showed no pearls in the resin surface after the pull out test, thus they were still attached to the ceramic inner surface.

Correlating the bond strength values to the area of the preparation surface (112 mm^2) gave values of 11.4 MPa for untreated alumina, 15.8 MPa for untreated zirconia, 20.7 MPa for zirconia + glass pearls and 23.4 MPa for zirconia + silanized glass pearls.

Table 1. *Surface roughness (Ra) of alumina and zirconia copings; untreated and after sandblasting with 50 and 110 µm particles respectively. Measures were done on five different positions of each specimen (µm).*

Material	*untreated*	*sand 50µm*	*sand 110 µm*
Zirconia	2.31±0.41	0.32±0.035	0.89±0.06
Alumina	0.95±0.08	0.07±0.01	0.58±0.06

Table 2. *Pull out test values (N) of copings cemented with zinc phosphate cement (n=10).*

	Mean		*SD*
Zr untreated	652		113
Al untreated	575	* **	134
Zr sand 50 µm	342		128
Al sand 50 µm	447		40
Zr sand 110 µm	346		38
Al sand 110 µm	500		93

*significance: * = p<0.05*
*** = p<0.001*

Table 3. *Pull out test values (N) for alumina and zirconia copings after different surface treatments and luted with Panavia (n = 10)*

	Mean		*SD*
Al untreated	1279		255
Al sandblasted	1202	*	210
Zr untreated	1779		272
Zr sandblasted	1562	** **	513
Zr+glasspearls	2319		145
Zr+glass+silan	2620		310

*significans * =p<0.05*
*** =p<0.001*

Table 4. *Pull out test values (N) of untreated zirconia and alumina copings cemented with Variolink II and Panavia respectively (n=10)*

	Mean		*SD*
Al, Variolink	815	**	357
Zr, Variolink	1745	*	251
Al, Panavia	1279		255
Zr, Panavia	1779	*	272

*Significans * =p<0.05*
*** =p<0.001*

DISCUSSION

When ceramic crowns and fixed partial dentures are used it is necessary to obtain a reliable bond to the tooth structure and the ceramic inner surface. Using alumina or zirconia as coping material conventional zinc phosphate cement is possible as seating material giving a mechanical bond caused by micro irregularities [17]. However, in this study irregularities made by sandblasting decreased the retention for both alumina and zirconia copings. Apparently the production process gives rougher surfaces than the sandblasting process that possibly polish the surface [18,19]. The convergence angle and the total length of the preparation are of vital importance for the retention of conventional cements and in this study the used model fulfilled these criteria and the bond strength was reasonably high. However, when the clinical situation gives shorter and/or more conical preparations resin bond materials is a better alternative[20].

Bond strength of resin cements to ceramics has mostly been tested with a shear method which is quick and uncomplicated to perform and make is easy to study the influence of different surface treatments. However, pull out tests have been reported earlier and are considered to be more clinical relevant [21,22].

Steel models were used to secure fractures between the ceramic surfaces and the resin cements. The metal surface offer good adhesion to the resin material and the contraction of the resin secure its firm grip to the steel model. Consequently no traces of resin material were found on the ceramics.

The two well-known resin cements used in the present study gave the same retention values for zirconia but VarioLink II gave lower values in combination with alumina copings. Panavia 21 often give better adhesion to alumina compared to other resin cements and a possible explanation can be the phosphate containing monomer in Panavia 21 [23].

The main interest today is focused on zirconia. High retention values were measured when the zirconia inner surface was additionally treated with glass pearls and the values were even higher when silane was added which has also been reported in an earlier study [13]. This can be of clinical importance when lack of tooth substance makes ideal preparation impossible or in addition, when ceramic constructions are exposed to high biting forces.

The bond strength values were presented in N to avoid straight comparison from common one-force tests. Recalculated bond strength values in relation to the surface area resulted in somewhat lower values compared to some reports where conventional shear bond tests were performed [14,24]. This could be explained by the fact that the shear force was combined with tension in the pull out test. Furthermore, different resin cements ends up with a variety of bond values [25].

The range of the standard deviations was also expected as air and spots with low polymerisation always are incorporated in greater areas.

CONCLUSION

Within the limitation of present study it can be concluded that sandblasting negatively affect the retention of ceramics cemented with zinc phosphate cement. Composite resin cements give higher retention combined with zirconia compared to alumina and this effect can be even better treating the zirconia inner surface with a monolayer of glass pearls.

ACKNOWLEDGMENT

Procera Nobel Biocare, Göteborg, Sweden, supported this study

MANUFACTURERS´DETAILS

- Procera: Nobel Biocare, Göteborg, Sweden
- Roughness tester: Mitutoye Type 201 P, Japan
- Zinc phosphate: Heraeus Kulzer, Germany
- Panavia 21: Kuraray, Japan
- VarioLink II: Ivoclar Vivadent, Liechtenstein
- Universal testing machine: Instron, Buckinghamshire, England

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