Is It Necessary to Photoactivate the Adhesive System Inside Ceramic Laminate Veneers in a Luting Procedure?

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**Purpose:** To investigate the need for photoactivation of the adhesive system inside ceramic laminates before the luting procedure and to evaluate the color stability, nanohardness, and elastic modulus of the adhesive interface activated with singlewave and polywave light-curing units. **Materials and Methods:** A total of 44 lithium disilicate ceramic veneers (7.0 mm × 8.0 mm × 0.6 mm) were fabricated, bonded to enamel, and sorted into four experimental groups (n = 11 each) according to the type of light-curing unit (Radii-Cal [singlewave] or Valo [polywave]) and mode of adhesive system activation (with or without previous photoactivation). Two luting agents were used: the Tetric N-Bond adhesive system and Variolink Veneer resin cement. A visible ultraviolet spectrophotometer was used to evaluate the color stability before and after UVB artificial accelerated aging for 252, 504, and 756 hours (n = 8 samples from each group). A nanohardness tester under a load of 1,000 μN was used to evaluate the nanohardness and elastic modulus (n = 3 samples from each group). Data regarding the color stability and the mechanical properties (nanohardness and elastic modulus) were subjected to analysis of variance and Tukey protected least significant difference test (α = .05). **Results:** Prior activation of the adhesive system, the distinct light-curing units, and different aging periods exerted no significant difference on the color stability or mechanical properties of the resin cement (P > .05), except for in the group activated with Radii-Cal after 756 hours, in which the nonprevious activation showed lower color alteration compared to the previous photoactivation (P = .0285). Without prior activation of the adhesive with Valo, the polywave unit promoted higher nanohardness and elastic modulus values in the adhesive system (P < .05). **Conclusion:** In general, singlewave and polywave light-curing units promoted no difference in color stability or the mechanical properties of the adhesive interface. The prior curing of an adhesive system inside ceramic laminate is not necessary. Int J Prosthodont 2019;32:533–540. doi: 10.11607/ijp.6405

The demand for beautiful and harmonious smiles has increased the use of ceramic laminates, which are an esthetic restoration alternative involving minimal tooth preparation.1,2 The luting protocol is fundamentally important to these minimally invasive procedures because the success of ceramic restorations is determined by the strength and durability of the bonding among the luting agents, ceramic material, and dental tissues.1,2 The optical properties of lithium disilicate reproduce the polychromatism, translucency, resistance, and compatibility of periodontal tissue, and the combination of lithium disilicate with ceramic/resin cement can mimic dental structures.1,3 In this context, resin cement contributes to the final esthetic quality of the restoration in addition to providing improved mechanical properties.1 The use of adhesive systems together with light-cured resin cements is the standard choice for luting ceramic laminates since they promote retention and resistance to fracture4 and facilitate improved color stability.5–7
An analysis of the properties of the materials applied in luting ceramic laminates is extremely important because the cementation line is exposed to the oral environment, which could potentially cause deterioration of mechanical properties via dissolution or leaching of components such as unpolymerized resin monomers. This degradation can directly affect the chemical, physical, and mechanical properties of the polymer, resulting in color changes of the ceramic laminates.

During the luting process of ceramic laminates, the requirements for application and prior photoactivation of the adhesive systems inside the ceramic laminate have been questioned. In some cases, these processes can be performed concomitantly with the activation of the light-cured resin cement, although little information is available in the dentistry literature regarding this issue. When the resin cement or adhesive system is exclusively light cured, it may not completely polymerize due to light attenuation caused by the opacity of the materials and restoration thickness. Thus, the correct activation of the resin materials used in the luting of ceramic laminates is important for the esthetic and mechanical longevity of restorations.

Camphorquinone is the most commonly used photoinitiator in resinous materials, but other types of photoinitiators have recently been introduced to the dental market, including Ivcocerin (Ivoclar Vivadent) and phenylpropanedione. With the development of improved resin materials, new versions of light-curing units have also been developed, such as the improved singlewave and polywave LEDs, which have one wavelength and multiple diode emissions, respectively.

In this in vitro study investigated the need for prior photoactivation of the adhesive system inside ceramic laminates before the luting procedure. The effect of singlewave and polywave light-curing units on the color stability, nanohardness (HIT), and elastic modulus (Ei*) of the adhesive system and resin cement in ceramic laminates subjected to ultraviolet (UV) aging was evaluated. The null hypotheses tested were: (1) Prior photoactivation of the adhesive system would not result in a significant difference in the color stability or mechanical properties (HIT, Ei*) of the adhesive system and resin cement; (2) Different aging periods would not cause significant differences in the color stability; and (3) Different light-curing units would not cause significant differences in the color stability of the ceramic laminates or mechanical properties (HIT, Ei*) of the adhesive system and resin cement.

### MATERIALS AND METHODS

#### Specimen Preparation

A total of 44 lithium disilicate ceramic veneers (7.0 mm × 8.0 mm × 0.6 mm) were fabricated from blocks of e.max CAD (IPS e.max CAD/high-translucency, shade B1, Ivoclar Vivadent) with a diamond saw under water irrigation with an Isomet 5,000 (Buehler) instrument. After obtaining the ceramic veneers, they were sintered in an oven (Programat EP 5,000, Ivoclar Vivadent) at 780°C for 1 hour according to manufacturer recommendations.

This study was evaluated and approved by the Ethics Committee on the Use of Animals of the Araçatuba School of Dentistry, São Paulo State University (#2015-00673). The resin-based luting agents used in the study are shown in Table 1.

#### Table 1: Materials, Composition, and Batch Number of Materials Used

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Batch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetric N-Bond adhesive system (Ivoclar Vivadent)</td>
<td>Bis-GMA, UDMA, dimethacrylate, HEMA, phosphonic acid acrylate, nanofillers (SiO2), ethanol, initiators and stabilizers</td>
<td>U18895</td>
</tr>
<tr>
<td>Variolink Veneer resin cement (Ivoclar Vivadent)</td>
<td>Dimethacrylates, inorganic fillers, ytterbium trifluoride, catalysts and stabilizers, pigments</td>
<td>U13581</td>
</tr>
<tr>
<td>Monobond Plus ceramic primer (Ivoclar Vivadent)</td>
<td>Ethanol, 3-trimethoxysilypropyl methacrylate, 10-MDP, disulfide acrylate</td>
<td>U29879</td>
</tr>
</tbody>
</table>

Bis-GMA = Bisphenol-A glycidyl methacrylate; UDMA = Uretane dimethacrylate; HEMA = 2-hydroxyethyl methacrylate; MDP = 10-Methacryloyloxydecyl dihydrogen phosphate.

The resin-based luting agents used in the study are shown in Table 1. A total of 44 bovine teeth were used, and all teeth that exhibited fractures and/or cracks were excluded. Anatomical crowns were removed from the roots 1.0 mm above the cemento-enamel joint through a transversal section with a diamond saw under water irrigation with an Isomet 5,000 instrument to obtain the tooth specimens (7.0 mm × 8.0 mm × 4.0 mm). The vestibular surface of the teeth was flattened with #600 silicon carbide paper (Extec) and divided into four groups of 11 each.

In the VALOWPC group, the enamel was conditioned with 37% phosphoric acid (Dentsply) for 30 seconds, then washed with deionized water and dried with air jets. The Tetric N-Bond (Ivoclar Vivadent) adhesive system was applied for 20 seconds to this surface, and then an air jet was applied for 5 seconds without curing. The inner surface of the lithium disilicate was conditioned with 10% hydrofluoric acid (Dentsply) for 20 seconds. Subsequently, air/water jets were used to remove residues resulting from the acid etching, and the surface was subsequently dried with air jets. Monobond Plus (Ivoclar Vivadent) silane was applied to the conditioned surface for 60 seconds and subsequently air dried for 5...
seconds.\textsuperscript{1,19} Then, a layer of Tetric N-Bond adhesive was applied, and the solvent was evaporated by applying air jets to the adhesive for 20 seconds without activation. Medium-value Variolink Veneer (Ivoclar Vivadent) resin cement was directly dispensed into the ceramic laminate to avoid bubble formation, bringing the ceramic into position on the dental substrate. Prior to the light-curing process, a load of 4.9 N was placed on the set in order to standardize the resin cement thickness and was thus removed. Excess of light-cured resin cement was removed with a microbrush, and the assembly was subsequently cured using a Valo polywave LED (Ultradent) light-curing unit for 30 seconds inside an opaque black box to avoid external light influence. The light intensity of the light-curing unit through the ceramic laminate veneer was 1,253 mW/cm\(^2\), according to the radiometer (Dabi Atlante RD7 Ecel).

In the VALOPC group, the same procedure was performed as described above, but the Tetric N-Bond adhesive system contained on the ceramic laminate surface was previously light cured for 10 seconds using a Valo polywave LED (Ultradent) light-curing unit.

In the RADIWPC group, the same treatment as applied to the first group was performed. However, photoinitiation of the adhesive system and resin cement was performed using the Radii-Cal singlewave LED (SDI) light-curing unit. The light intensity of the light-curing unit through the ceramic laminate veneer was 1,041 mW/cm\(^2\).

In the RADIIPC group, the same treatment as applied to the VALOPC group was performed. However, photoinitiation of the adhesive system and resin cement was performed using the Radii-Cal singlewave LED (SDI) light-curing unit.

All samples were stored in 37°C distilled water for 24 hours in light-protected containers. For the color stability investigation, 32 specimens were used (n = 8 from each group), and for mechanical property analyses, 12 were used (n = 3 from each group).

Color Stability Analysis

The baseline color of each sample (ceramic luted to the tooth) was measured according to the CIE L*a*b* (Commission Internationale de l’Eclairage) color system using a reflection spectrophotometer (model UV–2450, Shimadzu) over a white background and using the standard illuminant D65. The CIELab color space graph facilitates the three-dimensional measurement of color: “L” refers to the lightness parameter, with values ranging from 0 for total black to 100 for total white; and “a” and “b” are chromaticity coordinates on the green-red (−a = green; +a = red) and blue-yellow (−b = blue; +b = yellow) axes. Five color-analysis readings were collected for each sample through the ceramic laminate, and the values were subsequently averaged.

After the initial color measurement, the specimens from each experimental group were aged using an EQUV UV-accelerated aging machine (Equilam, Diadema), according to the American Society for Testing and Materials (ASTM protocol G154). A total of eight fluorescent lamps (40 W each) were used. The samples were submitted to specific periods of UV light and condensation with distilled water saturated with oxygen under heated conditions and 100% relative humidity. Each aging cycle was run for 12 hours and consisted of 8 hours of UV light application at 60 ± 3°C and 4 hours of a condensation period without light at 45 ± 3°C.\textsuperscript{20,21} This test was performed for three aging periods of 252, 504, and 756 hours. Color readings were taken after each aging period (21 cycles), 84 hours of condensation, and 168 hours of UVB light exposure with a 313-nm emission peak. The color change measurements were performed after the aging processes in the same manner as related above. The color difference after aging was calculated using the color coordinates before (baseline) and after the aging treatments, as measured in reflectance mode by applying the equation:

\[
\Delta E = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2}
\]

\(\Delta E\) is color difference; \(\Delta L^*\) is \(L_{\text{after aging}} - L_{\text{baseline}}\); \(\Delta a^*\) is \(a_{\text{after aging}} - a_{\text{baseline}}\); and \(\Delta b^*\) is \(b_{\text{after aging}} - b_{\text{baseline}}\).

The samples were kept in Hanks’ solution (Sigma Chemical) at 37°C until the color reading was taken.\textsuperscript{1}

Analysis of Mechanical Properties

Twelve samples (n = 3 from each group) were sectioned with a diamond saw coupled with a cutter machine (Isomet 5,000, Buehler) (Fig 1a) to obtain three slices of the mean portion of the sample (Fig 1b). These slices were fixed in acrylic resin (Classico), manually finished with 320-, 600-, 800-, and 1,200-grit silicon carbide papers (Extec), and polished using diamond pastes (6, 3, 1, and 0.25 μm) for 3 minutes for each phase (Fig 1c). The samples were cleaned using an ultrasonic unit (Cristofoli) with deionized water for a period of 8 minutes between each of the finishing and polishing steps. Subsequently, the samples were stored in Hanks’ balanced salt solution (Sigma Chemical) in order to maintain the pH and prevent cell degradation.\textsuperscript{1}

The mechanical properties nanohardness (HIT) and elastic modulus (Eit*) were evaluated using a nano-hardness machine (NHT\textsubscript{nano}, Anton Paar). The Berkovich diamond tip was used under force of 1,000 μN, and a standard trapezoidal loading function of 5-2-5 seconds was adopted (Fig 1d).\textsuperscript{22-24} Six measurements were taken on two different substrates at the bonding interface in all samples: three indentations in the resin cement and three indentations in the adhesive system.
Eit* data were measured according to the following formula:

\[ E_{it} = E^* (1 - \nu_s^2) \]

\[ E^* = \frac{1}{1 - 1 - \nu_i^2} \frac{E_r}{E_i} \]

\( E_r \) is the reduced modulus, \( E_i \) is the indenter tip elasticity modulus, \( \nu_i \) is the Poisson rate of the diamond indenter tip, and \( \nu_s \) is the Poisson rate of the investigated material. The mechanical properties values were automatically calculated by the nanohardness machine software.

**Statistical Analyses**

Statistical analyses were performed using a three-way repeated measures analysis of variance (ANOVA) for the color stability analysis and two-way ANOVA for the mechanical property analysis. The Tukey protected least significant difference test (\( \alpha = .05 \)) was also performed for both analyses.

**RESULTS**

The results of the three-way repeated measures ANOVA for color stability are shown in Table 2. No statistically significant difference between the light-curing units under the same experimental conditions or among various aging periods were found (\( P > .05 \), Table 3). For the period of analysis of 756 hours, the nonprevious adhesive activation presented lower color alteration than the previous photoactivation of the adhesive system when the Radii-Cal singlewave light-curing unit was used (\( P = .0285 \), Table 3).

The results of the two-way ANOVA for HIT and Eit* values for the resin cement and adhesive systems are shown in Tables 4, 5, 6, and 7, respectively. The resin cement showed no statistically significant difference between the HIT and Eit* values of samples prepared with the different light-curing units or

\[ \text{HIT} = \frac{P_{\text{MAX}}}{A} \]

\( P_{\text{MAX}} \) is the total loading and \( A \) is the relationship surface between the indenter tip and the sample at the total loading applied.

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**Fig 1** Specimen preparation for nanohardness (HIT) and elastic modulus (Eit*) analysis. (a) Sectioning of specimens. (b) Obtaining specimen slices of 2.0 mm in thickness. (c) Finishing and polishing process of the specimens using silicon carbide papers and diamond polishing pastes. (d) Evaluation of HIT and Eit* of the adhesive interface under load of 1,000 μN.

**Fig 2** Representative image of the adhesive interface obtained by laser scanning confocal microscope. A = ceramic substrate; B = adhesive system previously photoactivated in the ceramic substrate, with nanoindentation in the adhesive system contained in the ceramic substrate (arrow); C = resin cement layer, with nanoindentation in the resin cement (arrow); D = enamel substrate.
those exposed to different modes of activation of the adhesive system \((P > .05, \text{Table 8})\).

When comparing the modes of activation, prior curing of the dental adhesive in the ceramic laminate group with the Valo polywave LED light-curing unit resulted in lower HIT \((P = .0139)\) and Eit* \((P = .0293)\) values than without the prior curing (Table 8). Comparing the light-curing units, the Radii-Cal unit promoted higher Eit* values than the Valo polywave light-curing unit for both modes of activation of the adhesive system \((P < .05, \text{Table 8})\).

**DISCUSSION**

The group that was light cured with the Valo polywave unit without prior curing exhibited significantly higher HIT and Eit* values of the adhesive than the prior-curing group. The Radii-Cal singlewave light-curing unit promoted significantly higher Eit* values of the adhesive than the Valo polywave unit for both modes of activation of the adhesive system (Table 8). These findings indicate that the first and third null hypotheses could be rejected. The second null hypothesis was accepted because no statistically significant difference was found between the different aging times.

Accelerated artificial aging methodology has been applied for analyzing the color stability of dental materials, such as luting agents and dental ceramics, because it simulates conditions of the oral environment. ASTM protocol G154 allows inducing property changes of the materials, including the UV sunlight effect, heat, and moisture.25 Usually, these exposures include moisture in the condensing humidity form.25 This protocol is adopted such as a practice or method that defines specific conditions of exposure in order to evaluate the physical and chemical changes of these materials.20,21 Chromatic alteration may occur due to iatrogenic reasons such as inadequate polymerization; extrinsic factors such as UV irradiation, humidity, or heat; or intrinsic factors such as matrix composition of the luting agents or hydrolytic degradation of the resinous matrix.19

According to Malacarne-Zanon et al,28 the presence and incorporation of water in the resin materials are directly related to their degree of solubility, resulting in a significant impact on the clinical behavior of these materials. A higher concentration of water can result in irreversible alterations, such as hydrolytic degradation of the chemical components of the resinous matrix.2 Light-curing units may present intense light effects, generating thermal cycles and producing moisture in the condensing humidity forms.25 These alterations change the physical characteristics of the resin materials, such as the UV sun light effect, temperature, and moisture.25 This protocol is adopted such as a practice or method that defines specific conditions of exposure in order to evaluate the physical and chemical changes of these materials.20,21 Chromatic alteration may usually occur due to iatrogenic reasons such as inadequate polymerization; extrinsic factors such as UV irradiation, humidity, or heat; or intrinsic factors such as matrix composition of the luting agents or hydrolytic degradation of the resinous matrix.19

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**Table 2 Three-Way Repeated Measures ANOVA for Color Stability Values**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-curing unit</td>
<td>1</td>
<td>2.112</td>
<td>2.112</td>
<td>.219</td>
<td>.6433</td>
</tr>
<tr>
<td>Activation</td>
<td>1</td>
<td>39.351</td>
<td>39.351</td>
<td>4.084</td>
<td>.0530</td>
</tr>
<tr>
<td>Light-curing unit*Activation</td>
<td>1</td>
<td>50.238</td>
<td>50.238</td>
<td>5.214</td>
<td>.0320</td>
</tr>
<tr>
<td>Subject (group)</td>
<td>28</td>
<td>269.801</td>
<td>9.636</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category for color alteration</td>
<td>2</td>
<td>98.599</td>
<td>49.299</td>
<td>5.860</td>
<td>.0049</td>
</tr>
<tr>
<td>Category for color alteration* light-curing unit</td>
<td>2</td>
<td>1.462</td>
<td>.731</td>
<td>.087</td>
<td>.9169</td>
</tr>
<tr>
<td>Category for color alteration*Activation</td>
<td>2</td>
<td>11.020</td>
<td>5.510</td>
<td>.655</td>
<td>.5234</td>
</tr>
<tr>
<td>Category for color alteration* Light-curing unit*Activation</td>
<td>2</td>
<td>14.095</td>
<td>7.047</td>
<td>.838</td>
<td>.4380</td>
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<tr>
<td>Category for color alteration* Subject (group)</td>
<td>56</td>
<td>471.105</td>
<td>8.413</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means followed by distinct superscript letters (upper case in the columns for each light-curing unit, lower case in the rows for each mode of activation) indicate statistically significant differences \((P < .05)\).

**Table 3 Mean Color Change Values \((\Delta E) \pm Standard Deviation as Function of Aging Period, Light-Curing Unit, and Mode of Activation of Tetric N-Bond Adhesive System**

<table>
<thead>
<tr>
<th></th>
<th>Without prior curing</th>
<th>Prior curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>252 h</td>
<td>4.74 ± 3.10&lt;sup&gt;A,a&lt;/sup&gt;</td>
<td>4.74 ± 1.88&lt;sup&gt;A,a&lt;/sup&gt;</td>
</tr>
<tr>
<td>504 h</td>
<td>7.29 ± 3.51&lt;sup&gt;A,a&lt;/sup&gt;</td>
<td>5.97 ± 2.23&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>756 h</td>
<td>6.93 ± 4.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.75 ± 2.96&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Radii-Cal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>252 h</td>
<td>4.66 ± 1.83&lt;sup&gt;A,a&lt;/sup&gt;</td>
<td>5.76 ± 2.78&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>504 h</td>
<td>5.34 ± 2.32&lt;sup&gt;A,a&lt;/sup&gt;</td>
<td>8.87 ± 4.05&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>756 h</td>
<td>5.51 ± 1.66&lt;sup&gt;A,b&lt;/sup&gt;</td>
<td>9.07 ± 3.78&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means followed by distinct superscript letters (upper case in the columns for each light-curing unit, lower case in the rows for each mode of activation) indicate statistically significant differences \((P < .05)\).
The color change of materials after UV irradiation is related to chemical alteration in the activators of the initiator system and in the resinous matrix itself. Residual amine degradation and C-C oxidation can also result in the formation of yellowing compounds.20

From Table 8, it can be noted that the HIT data of the adhesive that was light activated with the Valo polywave unit were influenced by the previous activation of the Tetric N-Bond adhesive. It can be speculated that the group without prior curing exhibited higher HIT values than the group with prior curing of the adhesive system with the Valo polywave unit group due to the mixing of the luting agents. The agents included the monomers of the adhesive system and the monomers and load fillers from the resin cement, which resulted in higher HIT values of that substrate.31 It should be noted that the nanoindentation test allows the indirect investigation of the satisfactoriness of monomer conversion into polymers, where higher hardness values indicate improved mechanical properties of the luting material.32

Thus, based on the color stability, nanohardness, and elastic modulus of the adhesive interfaces, the prior activation of the adhesive system and the use of singlewave and polywave units promoted no significant differences in the measured parameters. However, other variables such as marginal adaptation analysis and bonding strength should be investigated in a follow-up study. Some limiting factors should also be considered, such as the use of only one resin cement, translucency of the ceramic, the adhesive system used, and the use of commercial light-curing units, which could show a non-uniform beam profile. Therefore, examination of other physical properties is essential for the development of luting techniques to increase the clinical longevity of ceramic laminates.
CONCLUSIONS

Based on the methodology used and results obtained in this research, it can be concluded that prior curing of an adhesive system inside ceramic laminate is not necessary. The color stability and mechanical properties of the resin cement were not influenced by the different light-curing units. The prior curing of the dental adhesive polymerized with the Valo polywave light-curing unit resulted in lower mechanical properties of the adhesive compared to no prior curing.

ACKNOWLEDGMENTS

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REFERENCES


Table 8 Mean (Standard Deviation) Values of Nanohardness (HIT [MPa]) and Elastic Modulus (Eit* [GPa]) of Variolink Veneer Resin Cement and Tetric N-Bond Adhesive System as Function of Light-Curing Unit and Mode of Activation of Adhesive System

<table>
<thead>
<tr>
<th></th>
<th>Without prior curing</th>
<th>Prior curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIT Valo</td>
<td>510.50 ± 64.89</td>
<td>500.30 ± 83.58</td>
</tr>
<tr>
<td></td>
<td>482.76 ± 52.72</td>
<td>433.44 ± 96.86</td>
</tr>
<tr>
<td>Eit* Valo</td>
<td>9.06 ± 1.10</td>
<td>9.44 ± 1.32</td>
</tr>
<tr>
<td></td>
<td>8.91 ± 0.74</td>
<td>8.48 ± 0.81</td>
</tr>
<tr>
<td>Tetric N-Bond</td>
<td>182.55 ± 14.29</td>
<td>156.86 ± 24.00</td>
</tr>
<tr>
<td></td>
<td>171.01 ± 16.78</td>
<td>149.31 ± 34.47</td>
</tr>
<tr>
<td>Eit* Valo</td>
<td>3.22 ± 0.22</td>
<td>3.02 ± 0.12</td>
</tr>
<tr>
<td></td>
<td>3.46 ± 0.20</td>
<td>3.56 ± 0.37</td>
</tr>
</tbody>
</table>

Means followed by direct superscript letters (uppercase in the columns for mode of activation and lowercase in the rows for light-curing unit) indicate statistically significant differences for each mechanical property analyzed for resin cement and adhesive system (P < .05).

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Literature Abstracts

Outcome of Posterior Fixed Dental Prostheses Made From Veneered Zirconia Over an Observation Period of Up to 13 Years

It was the aim of this clinical study to evaluate the long-term outcomes of three- to four-unit posterior all-ceramic fixed dental prostheses (FDPs) made from veneered zirconia ceramic. Between June 2003 and February 2005, 48 patients received 58 restorations. Of these restorations, 24 had a fixed-to-fixed design (FF) and 34 had a cantilever design (CA). Frameworks were scanned and milled out of 3 mol% yttrium-oxide partially stabilized zirconia ceramic (Cercon Base 30, Degudent) and were veneered with feldspathic ceramic (Cercon Ceram S, Degudent). All FDPs were cemented with glass-ionomer cement (Ketac Cem, 3M ESPE) after airborne-particle abrasion of the inner crown surfaces. The mean observation period was 85.4 ± 54 months for the FF group and 91.7 ± 50 months for the CA group. Ten CA FDPs and 5 FF FDPs were lost due to biologic problems with the abutment teeth, and 2 CA FDPs and 4 FF FDPs were lost due to technical failures of the ceramic materials. The cumulative 13-year survival rate was 43.2% (CI 22.8% to 66.2%) for FF FDPs and 52.5% (CI 32.5% to 71.8%) for CA FDPs. In 13 cases, intraoral repair or polishing of the fractured feldspathic ceramic veneers was needed (7 FF, 6 CA). Eight abutments of 6 restorations (4 FF, 4 CA) had to be treated endodontically, and caries therapy was needed in 6 abutment teeth (4 FF, 2 CA). The cumulative 13-year success rate was 29.5% (CI 12.1% to 55.9%) for FF FDPs and 22.5% (CI 7.9% to 49.3%) for CA FDPs. Within the limitations of the present investigation, posterior FDPs made from veneered zirconia with either an FF or a CA design showed comparable survival and success rates after 13 years of clinical observation. FDPs made from veneered zirconia ceramic present high failure and complication rates irrespective of the design.

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Stud vs Bar Attachments for Maxillary Four-Implant–Supported Overdentures: 3- to 9-year Results from a Retrospective Study

The aim of this study was to compare the clinical outcomes of four-implant–supported overdentures retained by stud or bar attachments in patients with edentulous maxillae. From January 2008 to December 2014, patients with edentulous maxillae were enrolled in this retrospective study. The insertion of four maxillary dental implants was followed by restoration with either stud-retained or bar-retained overdentures. The characteristics of the subjects and implants were recorded. Implant survival rates, marginal bone loss, peri-implant clinical parameters, and prosthetic maintenance efforts were evaluated at the final follow-up time. Patients were also asked to complete a satisfaction questionnaire using a modified Denture Satisfaction scale at their final follow-up visit. The data were statistically analyzed, and the level of significance was set at α = .05. A total of 132 implants were placed in 33 patients, of whom 18 were restored with 4-implant–supported overdentures retained by stud attachments and 15 with overdentures retained by bar attachments. A total of 31 patients and 124 implants were available for the entire follow-up period. During a mean follow-up period of 77 months (range 36 to 111 months), 5 of the 72 implants in the stud-retained group failed for 3 patients and 2 of 60 implants in the bar-retained group failed for 2 patients, resulting in estimated cumulative implant survival rates of 81.4% and 86.2% for the stud- and bar-retained groups, respectively. Except for the modified Plaque Index (P = .035), no significant differences were indicated between the two attachment groups in terms of implant survival rate, marginal bone loss, or peri-implant clinical parameters. Peri-implant gingival hyperplasia occurred only with implants under bar attachments. Over the entire observation period, the incidence of prosthetic maintenance treatments was 2.12 per patient per study for the stud-retained group and 2.29 per patient per study for the bar-retained group. Patients in both groups reported a high degree of satisfaction. Within the limitations of this study, no significant differences were indicated between the clinical outcomes of maxillary 4-implant–supported overdentures with either stud or bar attachments, although a higher modified Plaque Index was observed for the bar-retained group. Furthermore, prostheses with stud attachments were advantageous for their convenient cleaning and repair. Patients with compromised systemic and periodontal conditions should be treated with caution. Further clinical studies with larger sample sizes and stricter epidemiologic designs are still needed.