

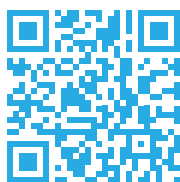
# ALL CERAMIC CEMENTATION PROTOCOLS AND RESIN CEMENTS FOR BONDING: A KEY TO SUCCESS

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## ABSTRACT

**BACK GROUND:** All ceramics are the trend of esthetic dentistry. Many a times there is still a hesitation among dentists to opt for these restorations. This fear is due to the lack of knowledge about the cementation procedure to be performed based on the type of ceramic chosen.

**AIM:** The aim of this article is to familiarise the clinicians with a wide array of cements available for all ceramic cementation and the protocols for cementing these restorations.

**METHODOLOGY:** A systematic review was done to scrutinize the steps in ceramic cementation and to analyse the available resin cements for bonding. A search was conducted using PubMed and Medline correlated with hand search for any relevant papers from the year 2000 till 2018 for articles related to cementation procedures and bonding with resin cements using keywords like self-etching, self-adhesive, total etch, resin cements and bonding.

**REVIEW RESULTS:** Ceramic cementation depends on the type of ceramic chosen. The choice of the luting agent is again multi factorial. However the dentist should clearly analyse and choose the right luting agent. Certain results from studies were difficult to compare because of different parameters used in each study especially pertaining to surface treatment procedures related to ceramic surface for bonding.

**CONCLUSIONS:** Ceramics are well-placed to satisfy aesthetic requirement and to fulfil functional requirements. A thorough knowledge about the ceramics will guide the dentist to select the appropriate luting agent and avoid the confusion. Cementation and technique sensitive procedures that reduces the restorations longevity should be carefully evaluated.

**KEYWORDS:** systematic review, cementation, bonding, luting

## INTRODUCTION:

Evolution of ceramics over the last decade has made it as one of the esthetic restorative material. Ceramics has now become the choice for all the dentists irrespective of the speciality. The confusion of choosing the cementation procedure exists due to the lack of sufficient knowledge about the types of ceramics and the appropriate cementation procedure suited for each of them. This article aims to give a broader vision about the ceramics and the cementation protocols.

## HISTORY OF CERAMIC RETENTION:

It was in 1885, Logan solved the problem of retention between porcelain crowns and posts by fusing the porcelain crowns to platinum posts popularly called as the Richmond crown.<sup>1</sup>

In 1886, Land introduced fused feldspathic porcelain inlays and crowns by using a burnished platinum foil as a substructure.

In 1950, the addition of leucite to porcelain formulations elevated the coefficient of thermal expansion to allow the fusion of ceramic to gold alloys.

The idea of replacing the metal core substructure with an opaque white substructure came in 1960s. In 1965, Mc Lean and Hughes developed a porcelain jacket crown with an inner core of aluminous porcelain with 40- 50% alumina crystals preventing crack propagation. But they were cemented using zinc phosphate cement that was not able to bond with the porcelain.

It was only in 1970s the concept of bonding was accepted by the dental profession. In 1980s then it became possible to bond the dentin and the porcelain with the intervening resin cement.

In 1990 newer form of ceramic crowns which were better not only in esthetics but can be bonded directly to the tooth structure came into existence starting from glass ceramics, then machinable glass ceramics to apatite glass ceramics followed by CAD

CAM ceramics.<sup>1</sup>

It was in 1985 the CEREC 1 was introduced followed by CEREC 2 in 1984 and CEREC 3 in 2000. The introduction of CEREC 3D in 2005 marked the three dimensional virtual display of the prepared tooth. All these advances made possible the accurate fabrication of all ceramic restorations which can be bonded with resin cements that further improved retention.

## CONCEPTS ABOUT CEMENTATION BASED ON THE TYPES OF CERAMICS:

Dental ceramics can be classified according to the matrix material, filler and dopant. Three main categories in accordance with this are: predominantly glass, particle- filled glass and polycrystalline non-glass ceramics.<sup>2</sup>

### PREDOMINANTLY GLASS CERAMICS:

These ceramics contain feldspar, silicon and aluminium oxides. It is biocompatible, resistant to abrasion and compressive forces. Though it is highly esthetic it has low strength and toughness when compared to other types of ceramics. To overcome the low bond strength, adhesive cementation should be performed to increase the restoration's resistance to fracture.<sup>3</sup>

Conditioning of the ceramic surface is a prerequisite before adhesive cementation. First, etching is done with a solution of hydrofluoric acid in concentrations of about 5 and 10 % for approximately 1 minute. Etching is done to provide increased surface area and provide micro mechanical retention as proposed by Navez et al.<sup>4</sup>

It also causes selective dissolution of the glassy phase of the ceramic and makes it porous. This porous surface forms hydroxyl groups on the surface of the ceramic that aids in chemical adhesion to the resin cements via the silane coupling agents.<sup>5</sup> Silanes are hybrid inorganic-organo- functional trialkoxysilane monomers that are chemically bifunctional. It has two groups i.e. non- hydrolysable groups such as

methacrylate and alkoxy hydrolysable groups.<sup>6</sup> When reactive silanes are applied over the etched ceramic surface, the hydrolysable alkoxy groups of the silanes react with the hydroxyl groups of the ceramic exposed through etching and non-hydrolysable organic groups reacts with unset resin cement.<sup>7</sup> Silane is applied for 1 minute and air dried. Silanes are available in two forms i.e. hydrolysed and unhydrolysed silanes. Hydrolysed silanes are one bottle systems. The effectiveness of pre-hydrolysed, single-bottle silane primers is unpredictable. A clear solution is usable but if the solution becomes milky white, it should be discarded.<sup>8</sup> However some one bottle systems are alcoholic based and hence it remains transparent and thus signs of any changes cannot be observed. Therefore it is preferable to use two bottle systems. It is better to strictly respect expiration date and adhere to manufacturer's recommendation for silanation. Before cementation, try in is done with try in pastes. Scientific evidences suggest that try in to be done after the ceramic surface is silanated. This is because the try in procedure itself will remove excessive silane from the ceramic surface which aids in proper coupling of the resin with mono layered silanated ceramic surface.<sup>9</sup> Bonding to the tooth requires the use of adhesive systems to bond enamel or dentin with the resin cements. For feldspathic porcelains of low strength it is recommended to use total etch (etch and rinse) followed by the use of dual cured resin cements for crowns and inlays and light cured resin cements for veneers. It is also ideal to follow the adhesive and resin cement combination that is recommended by the manufacturer.

Product examples of predominantly glass ceramics include Ceramco, IPS e. max Ceram, Vita VM 7, Lava Ceram, Creation, CEREC Blocs etc.

### **PARTICLE FILLED GLASS CERAMICS:**

This has a glassy matrix phase and different types of particles as fillers. These again can be classified based on the filler particles as low filled, intermediate filled and highly filled materials.<sup>10</sup>

Low filled materials include products like IPS Empress

Esthetic and OPC which are filled with leucite. As their strength is low it is mostly indicated for veneers, inlays and onlays and areas of low stress. Etching and silanation is the same as for feldspathic porcelain. It is then recommended to use total etch (etch and rinse) followed by the use of dual cured resin cements for inlays and onlays and light cured resin cements for veneers for cementation.

Intermediate filled includes product like IPS e max Press and OPC 3G which has lithium disilicate as fillers. It has strength and thus can be used for both partial and full coverage restorations. Both adhesive and non-adhesive cementation is indicated. Full coverage restorations can be conventionally luted with resin modified glass ionomer cements and partial coverage can be adhesively bonded.<sup>11</sup> First step in adhesive bonding is etching which is done with 5% hydrofluoric acid for 20 seconds followed by silanation where silanes are applied for 1 minute and air dried. In addition to etching, sandblasting is also recommended by some manufacturers. Self-etch and self-adhesive resin cements can be used for these ceramics. In self-etch resin cements, etching with phosphoric acid is eliminated. Instead the etchant is composed of acidic monomers and phosphate esters combined with primers and thus the name self-etch primers. The adhesive comes as two bottles which are dispensed in equal amounts and mixed followed by cementation done with dual cured resin cements. In self-adhesive type, the phosphoric acid is grafted in the resin matrix which reacts with the composite fillers forming a cross linked polymer that bonds to the dentin. No separate bonding procedure is required and thus called self-adhesive resin cements.

The highly filled type contains a sintered core of aluminium oxide infiltrated with molten glass. They have high strength and toughness due to the increase filler content. These are also called as glass infiltrated aluminium oxide ceramics. In-Ceram Spinell, In-Ceram Alumina and In-Ceram Zirconia are some examples of this type of ceramics. These type of ceramics do not require adhesive cementation. As the amount of glassy phase is very less, they cannot be etched. Etching doesn't increase the retention of

these resin cements.<sup>9</sup> But however researchers have concluded adhesive cementation is also possible with surface preparation. Surface preparation of the ceramic includes tribochemical silica coating and silanization as an effective method for achieving resin bonding.<sup>12</sup> For In-Ceram alumina, 10-methacryloyloxydecyl dihydrogen phosphate (MDP) containing resin cement and primer can be used. For In-Ceram zirconia, use of MDP monomer containing resin cement i.e. self-adhesive cements can be used.<sup>13</sup>

### **POLYCRYSTALLINE CERAMICS:**

These are densely sintered aluminium oxide or zirconium oxide ceramics. These ceramics have no glassy phase. Because their atoms are closely packed, they resist the propagation of cracks. They have high strength and toughness. Products of aluminium oxide ceramics are Procera alumina. Products of zirconium oxide are Cercon Zirconia, Lava Zirconia, Everest, IPS e.max ZirCAD, Katana, Procera allZirkon, CEREC inLab, Vita In-Ceram YZ etc. For aluminium oxide ceramics, particle abrasion using 50-110  $\mu$  AlO<sub>2</sub> at 2.5 bars is used for pre-treating the surface. For zirconia based ceramics, tribochemical silica coating is done first. Subsequently it can be cemented using an MDP monomer based resin cement i.e. self-adhesive resin cements can be used that are dual cured. If the tooth preparation has good retentive features, zirconia crowns can be cemented with conventional cements without bonding.<sup>14</sup>

### **A BRIEF OUTLOOK OF TYPES OF CEMENTS AVAILABLE FOR ALL CERAMIC CEMENTATION:**

There are different factors controlling the selection of cements used for all ceramic restorations. Clinical factors affecting the choice of cement are amount of retention required which is influenced by the preparation design (taper, length of the tooth remaining), proper isolation, esthetics and amount of remaining enamel or dentin.

The criteria for selection of the cement depends on ease of manipulation, esthetics, resistance to compression and flexion, obtaining adequate marginal closure, high bond strength that prevents the dislocation

of the restoration and marginal micro leakage.<sup>15</sup>

Though traditional cements like zinc phosphate are available, they are not used for all ceramic cementation due to their inferior compressive and flexural strength.

Glass ionomer cements undergo expansion, on an average of 1.7-1.8% during setting. They also expand when they absorb oral fluids. This is a disadvantage as this expansion causes crazing of the ceramic crowns as it transmits undue stress to the internal surface of the ceramic restoration.<sup>16</sup>

Resin modified glass ionomer cements are primarily used for metal and metal based restorations. They can also be used for cementing high strength alumina and zirconia ceramics. But they exhibit hygroscopic expansion on absorption of oral fluids and cannot be used for the cementation of low strength feldspathic crowns and veneers as this may cause clinical fractures.<sup>17</sup>

Resin cements are now the most commonly used cements for all ceramic restorations. The choice of the resin cementation system for adhesive cementation is critical. They are basically divided into two types as conventional and self-adhesive cements.

Conventional includes the total etch and self-etch type of resin cements.

The total etch involves etching enamel and dentin with 36-37% phosphoric acid on the tooth surface followed by the application of dentin bonding agent which is available as a single bottle system. They have high bond strengths to the dentin. Care has to be taken not to dry the tooth surface completely as some amount of moisture should be there in the dentinal surface to ensure optimal bonding.<sup>18</sup> It is then followed by cementation with resin cements. These cements require more number of steps for bonding and thus they are very technique sensitive. Indications for total etch cements are esthetic demand, anterior teeth where isolation is easy, low strength restoration such as veneers and preparations in the enamel. Total etch resin cements



come in various forms. They are available as two paste systems or powder paste systems. These cements should be used with the appropriate etchant and bonding agent as prescribed by the manufacturer.

The total etch resin cements are further classified based on the mode of curing as self-cure, dual cure and light cure resin cements. Some examples of self-cure total etch resin cements are C&B Metabond (Parkell), Comspan (Dentsply), C&B Cement (Bisco) and Superbond C&B (Sun Medical). These are not used for veneers as they have little working time, and exhibits colour change during aging due to the presence of the amine activator. Light cure cements are indicated for veneers. Some examples are Calibra (Dentsply) and Variolink (Ivoclar Vivadent). The self-etch resin cements contains acidic monomers and phosphate as etchant combined with the primer. Common acidic monomers used are 10-MDP, 4-META (4-methacryloyloxyethyl trimellitate anhydride) and GPDM (glycerol phosphate dimethacrylate). The adhesive to pre-treat the enamel comes in two bottles which are dispensed in equal amounts and thoroughly mixed. A common mistake in self-etch adhesives is failure to air dry after adhesive is applied. The adhesive should be air dried for about 5-10 seconds to remove the residual acidic hydrogen ions and ethanol. Self-etch cements are usually refrigerated as heat degrades the acidic monomers present. They are used when the preparation is in dentin, retention is less, for cementing debonded fixed prostheses, deep inlays and onlays with few walls remaining. The cements used mostly are dual cured. Some of the examples of dual cured resin cements include Panavia F, RelyX Unicem, Variolink 2 and Fuji Plus.

Self-adhesive resin cements or universal adhesive cements are the newest among resin cements. They do not require pre-treatment of the dentin. They do not use any adhesive system thus reducing the clinical steps and technique sensitivity. They have multifunctional phosphoric acid methacrylates which reacts with the hydroxyapatite of the tooth.<sup>19</sup> However they show lower bond strength when compared to the self-etch and total etch cements.<sup>20</sup> They can be used when retention is less, in short crowns, onlays with less number of

walls. They are the cements of choice for high strength ceramics like alumina and zirconia. They come in double barreled dispenser with an auto mix tip where the base and catalyst can be mixed and applied directly to the restoration. They also should be refrigerated as they have acidic monomers degradable by heat. They are mostly dual cured. Only contraindication of self-adhesive cements is not to be used for cementation of laminate veneers.<sup>21</sup> Some examples of self-adhesive cements are BisCem (Bisco, USA), Breeze (Pentron, USA), GCem (GC, Japan), MaxCem (Kerr, USA), Rely X Unicem (3M ESPE, USA), Embrace Wetbond (Pulpdent, USA), Multilink Sprint (Ivoclar Vivadent) and MonoCem (Shofu, USA).

### ROLE OF CEMENTS IN ESTHETICS OF CERAMIC CROWNS:

Cements play a critical role in affecting the final esthetics of all ceramic restorations especially in laminate veneers. As the veneers are thin, the translucent enamel reveals the underlying tooth color. Hence if the tooth color has to be masked, resin cements of different shades can be used to achieve acceptable esthetics. Vichi et al found that the color of the IPS Empress restorations was not affected by the color of the different substrates if the thickness of the restoration was more than 2mm. If the thickness is less than 1mm, then the substrate color will significantly influence the colour of the cemented restorations.<sup>22</sup>

The color of the veneer restorations is thus influenced by the shade and brand of resin cement, shade and brand of try in paste and porcelain thickness. Different shades of resin cements are available which may be clinically useful to change the color of the porcelain veneer restorations and this aids the color matching process. Also significant color changes were found between the try in pastes and their matched resin cements. However smaller changes were found between resins (which are either cured or uncured) for most of the shades and brands. Hence it is recommended to use a try in paste with caution in predicting the color of the final restoration and further assessment should be made with the resin in place before curing.<sup>23</sup> Some examples of esthetic resin cements are Panavia 21 (Kuraray), Rely X (3M ESPE), C&B Metabond (Parkell) etc.

## **MECHANISM OF RETENTION OF ALL CERAMIC CROWNS:**

Although silica/glass based all ceramic crowns has better esthetic properties they are mechanically weaker and hence should be used in conjunction with resin bonding cements to improve the strength. It is accepted that adhesion between ceramics and resin cements can be both micromechanical attachment and chemical bonding.

Silica based ceramics are usually etched by hydrofluoric acid with or without grit blasting for mechanical interlocking and then silanated to achieve micromechanical and chemical bonding to resin cements. The application of appropriate adhesive with correct technique will ensure the longevity of these restorations.<sup>24</sup>

Due to its inability to be etched by chemical agents, bonding of zirconia is difficult when compared to silica based ceramics. This is due to the crystalline surface of these high strength ceramics. Hence to create bonding various other methods are used like surface treatment with acidic methacrylates, laser irradiation, and depositing silica layers on the zirconia surface.

Successful adhesion depends on the use of appropriate surface treatment of the internal surface of the restoration. This will create a strong bond of the ceramic surface with the resin cement. Also studies have shown that surface treatments played a major role on adhesion strength of both zirconia based ceramics and glass ceramics.<sup>25</sup> However zirconia can also be luted with conventional cements if sufficient tooth structure contributes for retention.

## **FACTORS AFFECTING RETENTION OF ALL CERAMIC RESTORATIONS:**

There are different factors affecting the retention of all ceramic restoration. This includes the tooth preparation, choice of the cement (luting or bonding), and surface treatment of the restoration along with the conditioning of the tooth.

Generally for any restoration, a good tooth preparation based on fundamental principles is an important criteria. Hence the tooth preparation should be based on biological, mechanical and esthetic considerations. Retention also depends on magnitude of dislodging force, geometry of the tooth preparation, taper, surface area, stress concentrations and type of preparation.

Retentive features for an all ceramic crown includes minimal taper. Inadequate tooth reduction lingually or occlusally leads to loss of clearance and also diminished strength of porcelain leading to loss of retention. Improper finish lines can lead to micro leakage and hence loss of retention.

Retentive features for laminate veneers includes a modified chamfer. The preparation of this finish line should be done so as to expose the enamel rods in a correct angulation. This helps to achieve good retention with the resin cement. It also adds up to the bond strength at the cervical margin providing good retention. Etching the porcelain is also a predominant factor that contributes to retention.

Ceramic inlays and onlays includes tooth preparation whose design is governed by the amount of teeth affected by the carious lesion and the old restorations in situ. The outline form should not include occlusal contacts. For an onlay preparation, 1.5 mm clearance is needed in all excursions to avoid ceramic fracture. The internal line angles should be rounded to prevent stress concentrations that enhances retention. Final retention is achieved by bonding with a resin cement.<sup>26</sup>

Choice of the cement will also affect the retention. Adhesive cementation is the choice for the all ceramic restoration which increases retention for teeth with taper up to 14 degrees,  $\geq 4\text{mm}$  or  $< 4\text{mm}$  of crown length remaining, 2 or more walls or less than 2 remaining. Further surface treatment of the ceramic is also important as described above in the literature. Conditioning of the tooth also becomes vital to ensure bonding of the cement with the tooth. Ability to maintain a moisture free environment during bonding of all ceramic restorations also play a vital role in

retention.

## CONCLUSION:

The success of any restoration is not only patient related but also depends on the skill of the operating dentist. The skill of the dentist depends on the practise which is equipped with detailed knowledge about the materials used. Thus with knowledge, all ceramic restorations will reign dentistry for years to follow. It is the duty of the dentist to keep an update about the existing materials and the current innovations in all ceramic restorations to be in par with the speciality of esthetic dentistry.

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