



A Critical Review of the Composition, Mechanisms and Applications of Self Adhesive Resin Cement

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Abstract

Self-adhesive resin cements were introduced to minimize the complexity on the stage of luting of the resin cements and some disadvantages like susceptibility to humidity, possible post-operative sensibility. This review article will approach their chemical composition, setting reaction, and mechanism of adhesion. The result of this review about self-adhesive resin cement would suggest their application and clinical performance in comparison with other resin base and non-resin based cements.

Keywords

Self-adhesive resin cement; adhesion; substrate; Clinical performance

Introduction

The increase in aesthetic demand in dentistry has resulted in the improvement of metal-free restorations, from indirect composite resin restorations, as well as the various ceramic categories. However, the best clinical performance of these aesthetic restorative materials depended to a large extent on the cementing agents, which should have optical characteristics similar to natural dentition, with increased mechanical properties and improved adhesion to various types of substrates [1].

Conventional cements such as zinc phosphate, zinc polycarboxylate, glass ionomer did not have these characteristics, so it was necessary to develop a new material that obtained these characteristics [1].

With the advancement of adhesive dentistry, it was possible to develop resin cements, which acquired an important role in prosthetic dentistry. This type of luting agent has several advantages when compared to conventional luting agents [2].

As an example, it may have: increased retention, minimal solubility in the oral environment, less microleakage, an acceptable biocompatibility, high bond strength to the dental structure and restorative material, reinforcement to the dental substrate, in addition to contributing to a better aesthetic in prosthetic restorations [2].

The mechanism of adhesion of this type of cement to enamel and dentin involves the use of adhesive systems that increase the micromechanical bond to conditioned enamel and form a hybrid layer in dentin [3]. However, this cement class has some disadvantages, such as the incompatibility between simplified adhesive systems that have acidic and hydrophilic characteristics with conventional dual resin and chemical setting cements [1,4].

This incompatibility can be directly responsible for compromising the bond strength, drastically reducing the retention and maintenance of the restoration. Another disadvantage of conventional resin cements is their multiple stages, which makes their technique more sensitive [1,4].

To circumvent these disadvantages, a new class of resin cements was introduced in 2002. Self-adhesive resin cements are hybrid materials that feature the combination of composite resins, self-etching adhesives and glass ionomer [5-7].

It was designed with the purpose of overcoming some limitations of traditional and resinous conventional cements and gained great popularity among clinicians due to its simplified cementation protocol, not requiring a pretreatment on the dental surface, reducing the number of steps to a single step, decreasing the technical sensitivity, making the cementation process simple and faster [5-7].

Therefore, the use of this new class of resin cement, reduced the occurrence of postoperative sensitivity, decreased the risk of contamination and increased the retention of fiberglass pins. In addition, it has satisfactory adhesion to dentin and restorative materials, in addition to releasing fluoride by partially dissolving glass particles similar to glass ionomer cement [5-7].

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Although there is controversy and little information about the quality of this new luting agent, the objective of this work is to make a literature review addressing some of the characteristics such as: composition, setting mechanism, bond strength in different substrates, pH, sorption, solubility, besides other mechanical properties.

Composition

Currently, self-adhesive resin cements are sold in two pastes in separate packaging which need manual mixing or more popularly joined by a syringe with self-mixing applicator tip [7]. In the packages that are separated, the catalyst paste from the base paste, the components must be separated due to the possibility of acid-base interaction between the acid monomers and leachable ions of glass charge particles, with the chemical setting components, and the need to isolate the tertiary amines used in the photopolymerization mechanism of acid monomers [1].

The main components present in its composition: 1) aliphatic and aromatic methacrylate monomers that are responsible for cross-linking in the polymeric network, such as conventional mono, di and multi methacrylate monomers: Bis-GMA, UDMA, HEMA, GDMA, TEGDMA, TMPTMA, 2) acidic methacrylate monomers which have the function of adhering to enamel and dentin and copolymerizing with cross-linked monomers, 3) glass charge particles, such as barium fluoroaluminoborosilicate, calcium aluminosilicate, strontium, quartz, colloidal silica, ytterbium fluoride among others and / or basic components that neutralize residual acid monomers, 4) silanized particles that provide resistance, 5) catalysts and stabilizers that assist in dual setting 6) pigments and opacifiers that meet aesthetic requirements [1,7,8].

The use of functional monomers is important to achieve demineralization and at the same time adherence to the dental structure. Carboxylic group methacrylates such as 4 - META (methacryloxyethyl trimellitic anhydride), PMGDM (pyromellitic glycerol dimethacrylate) or phosphoric group, such as Phenyl P (2-methacryloxyethylphenyl hydrogenphosphate), 10 - MDP are predominant. dihydrogen, BMP (bis- (2-methacryloxyethyl) phosphate) and Penta - P (dipentaerythritol pentaacrylate monophosphate) [8].

These functional monomers based on phosphates or phosphonates have been developed due to their performance in demineralizing the enamel and dentin surface, promoting the formation of a stable salt that mainly involves the calcium of the dental substrate [7]. The selection of the structure of acid monomers is a critical factor, as they form a strongly insoluble salt in an aqueous medium between calcium ions and MDP, while 4 META and Phenyl P produce a complex with calcium that has a limited stability to dissolution [7].

The concentration of these acidic monomers in cements should be balanced so that they are low enough to avoid excessive hydrophilization in the final polymerization, but be high enough to achieve an acceptable degree of conditioning of dentin and enamel [7]. The free radicals of the polymerization of acid monomers replicate to a certain extent the potential for adhesion of polyalkyleneate cements (glass ionomer), allowing an acidic and non-acidic proportion of the monomers to be completely controlled. The excessive hydrophilic character can cause the swelling of the cement which can compromise the mechanical strength and dimensional stability [7].

Setting Reaction

Self-adhesive cements can present a chemical or dual setting reaction, with the chemical setting being extremely relevant, as photoactivation can be restricted by thickness, type of restorative material, with insufficient polymerization. Considering this combination of both cure base, it will be possible to have a higher final conversion and high bond strength [7].

This approach has been highlighted in the literature, which

indicates a greater conversion of methacrylate when the setting mode is dual than when compared only with chemical setting. A possible explanation for this finding may be related to the inability of free radicals to have mobility due to the change in viscosity during polymerization [9].

According to Shim et al. [10], who investigated the degree of conversion by polymerization modes: chemical and dual setting of 3 self-adhesive cements G-CEM LinkAce™ (GC America Inc, Alsip), Maxcem Elite™ (Kerr Corporation, Orange, CA), and BisCemVR (Bisco, Inc. Schaumburg, IL demonstrated the importance of the dual setting mode in which cements evaluated only with the chemical setting had the lowest degree of conversion than when subjected to dual setting. This may be related to the self-curing time of each cement that can last up to 2 weeks. The results confirmed that the lack of photopolymerization affected not only the initial polymerization stage, but also the final polymerization of the cement.

Another relevant factor in this study was that the polymerization potential and setting time may vary according to the brand of cement used. Regarding the initial chemical setting of the cement, which is more active, it is interesting to wait at least 5 minutes for the G-CEM LinkAce™ and Maxcem Elite™ and 30 minutes for the BisCemVR before starting the procedures for removing excess cement, finishing and polishing [10].

According to the work of Baena et al. [11] who used the micro hardness test to assess the degree of conversion of self-adhesive resin cements in the cementing of fiberglass posts after 24 hours, confirmed that the microhardness of the cements depended on the trademark, in addition, the degree of conversion in the thirds of the channel can be affected by the distance from the light source, showing the importance of cure by photoactivation, another relevant fact is that the polymerization reaction continued for more than 24 hours, reaching a significantly greater microhardness after one week [11].

Other factors that can influence cements according to Pegoraro et al. [12], are temperature and aging, where temperature above 30°C for prolonged periods can affect peroxides and inhibitors that are not stable chemical components, and may undergo degradation that can increase or shorten working and setting time [12].

If the inhibitors degrade quickly, the peroxides will react with the amines, accelerating the reaction and reducing the working time and subsequently the setting time, if the peroxide has an active concentration to react with the remaining amines. It is advisable that the cement be stored in refrigerated places to prolong its performance and its chemical stability, should be placed at room temperature before being used [12].

Adhesion Mechanism

Self-adhesive resin cements have self-etching characteristics in the early stages of the chemical reaction. The acidic functional monomers of the carboxylic and phosphoric groups simultaneously condition and infiltrate the enamel and dentin, binding to the calcium ions of the demineralized dentin hydroxyapatite and the surface of the restorative material, creating adhesion between them [13].

The adhesion mechanism of these materials is not based on the formation of a hybrid layer or formation of resinous tags, since only a partial smear layer on the dentin is demineralized or infiltrated. The ions released from the charge particles neutralize the remaining acid groups creating a chelator, reinforcing the three-dimensional methacrylate chain [7,13].

The concentration of acid monomers plays a fundamental role in the setting process, therefore, this concentration must be high enough to ensure proper demineralization, adhesion to dentin and enamel, and be low enough to avoid excessive hydrophilization of the cement setting [13].

According to Ferracane et al. [7], excessive hydrophilicity occurs due to the low pH in the setting of the material, which can

cause swelling that compromises mechanical stability as well as dimensional stability. This low pH and great hydrophilicity it affects the initial stages after mixing, producing moistening of the tooth structure and promoting demineralization, similar to the process of self-etching adhesive systems [7].

After taking cure, this acidity is gradually neutralized due to the reaction with the apatite of the dental structure and the metallic oxides present in the filler particles, thus consuming the acid monomers, making the cement more hydrophobic, which is quite acceptable in a resin cement for minimize sorption, hygroscopic expansion and hydrolytic degradation [7].

Self-adhesive cements present different levels of pH neutralization during the setting time. In general, the lowest neutralization is observed in the most hydrophilic cements [1,7].

Bond Strength To Different Substrates

Self-adhesive resin cements do not require a bonding agent or dental adhesive as a pretreatment prior to the luting step. However, a large amount of self-adhesive resin cements can benefit from an additional surface treatment prior to cementation, increasing its performance. A complete understanding of how self-adhesive cements interact and adhere to different substrates can be of great importance in choosing the best material in each clinical situation [1].

According to the study by Shekri et al [14] that evaluated the bond strength of the self-adhesive cement in the enamel to different surface treatments: group 1 control that applied only the self-adhesive cement, group 2 that had previous conditioning with phosphoric acid, group 3 previous conditioning with adhesive universal and group 4 previous conditioning with phosphoric acid and universal adhesive reported that conditioning before application increased the bond strength when compared to the control group [14].

In group 2, which used only phosphoric acid, the enamel roughness increased (subgroup A: 2.19 MPa; subgroup B: 2.38 MPa). Group 3 resulted only in a moderate conditioning pattern (subgroup A: 2.24 MPa; subgroup B: 2.49 MPa). Group 4 removed the smear layer and demineralized the enamel (subgroup A: 2.72 MPa; subgroup B: 2.97 MPa), conditioning it, resulting in a larger surface area and the resinous monomers penetrated inside the microporosities, adhering and forming resin tags thus generating greater micromechanical retention [14]. The variation of the enamel structure can also affect adhesion, studies have shown that the aprismatic enamel can negatively affect the bond strength, an example occurs in the region of the cervical third of the enamel that is more aprismatic, due to this morphology this region has less adhesion when compared to the coronal third of the enamel. Aprismatic enamel proves to be more acid resistant than prismatic enamel [14].

Self-adhesive resin cements may not completely infiltrate microporosities due to their viscosity when compared to the adhesive. The bond strength to traction was higher in the group that used phosphoric acid and adhesive together. The 10 MDP made chemical adhesion to the hydroxyapatite calcium, this could increase the bond strength in general. The pre-treatment of enamel with conditioning and or universal adhesives before the application of self-adhesive resin cement increased the bond strength to traction [14].

In the study by Rodrigues et al. [15], the bond strength of self-adhesive resin cements and a conventional resin cement (control) in enamel and dentin of bovine teeth was evaluated, with and without etching with phosphoric acid. The enamel results showed that the groups (E-U100: 5.14 MPa; E-U200: 5.29 MPa, E-ARC: 1.64 MPa) had the lowest shear bond strength values when compared with the groups that used conditioning with 37% phosphoric acid (EP 100: 17.81 MPa; EP U200: 17.52 MPa; EP ARC: 9.96 MPa) [15].

The control group (RelyX ARC) without conditioning showed a lower bond strength value (E-ARC: 1.64 MPa), due to the lack of functional monomers in its composition, thus, there was no demineralization and infiltration of the monomers in the enamel. The

groups of self-adhesive and conventional cements had similar bond strength when the previous stage of conditioning with phosphoric acid was used [15].

This increase may be due to the large amount of microscopic irregularities produced by 37% acid etching and the pressure used in cementation, this pressure can contribute to a reduction in the thickness and porosity of the cement, increasing the adaptation in the cavity. However, according to Rodrigues et al. [15]. This pressure had no influence on the final result of enamel bond strength [15].

Another study, Costa et al. [16], who evaluated the pH, cohesive strength and micro shear bond strength of two self-adhesive cements RelyX U-100 (3M / ESPE, St. Paul, USA) and seT PP (SDI, Bayswater, Australia in enamel and dentin of bovine incisors.

The use of these types of tests was due to the difficulty of executing the microtensile test on the enamel, because the cutting procedure to obtain the sticks produces defects in the corners, resulting in a large number of defects that compromises the test. Another advantage of this test is the possibility of using the same tooth to assess the bond strength in both enamel and dentin [16].

To interpret the bond strength results, it was necessary to analyze the pH of the interface produced by the self-adhesive cements. This interaction is dependent on the pH of the cement, therefore, it is extremely important that the cement has an acidic pH sufficient to ensure adequate demineralization of the cement, enamel, however, it should not be too acidic to avoid excessive hydrophilia, compromising the restoration [16].

The U-100 had less acidity, this is due to the presence of calcium hydroxide in its composition, which reacts with the functional monomers that will increase the neutralization of the cement. This explains why U-100 has a higher bond strength to the micro-shear bond in the enamel (10.7 MPa) and seT presented a lower value (4.8 MPa) [16].

Another possibility to explain the low bond strength presented by seT is the presence of the UDMA monomer, which has great flexibility, low resistance to flexion due to weak hydrogen bonds in the interaction (urethane-hydroxyl N-H interactions) [16].

The micromechanical interlocking of self-adhesive cements with the enamel surface depends on a more receptive surface, with this an enamel abrasion was performed with SiC 600 sandpaper. The use of this method apparently improved this interlock, and the cement probably had better conditions to interact with hydroxyapatite [16].

Although the low bond strength is expected in self-adhesive cements, the increase in bond strength can be achieved using previous application of phosphoric acid in the enamel [16].

Regarding dentin, according to the literature, when conditioning with phosphoric acid, there is no benefit in the application of self-adhesive cements. This conditioning showed an effective decrease in adhesion, probably due to the relative viscosity of the material and the limited penetration of cement in the network of collagen fibers [1,17].

In the study by Chavez-Lozada et al. [18], the bond strength of self-adhesive cements was compared with a conventional resin cement. The low bond strength was reported in the self-adhesive when compared with conventional resin cement, probably due to the low demineralization and infiltration capacity in the dentin substrate, although the initial pH is low, its high viscosity may be the probable explanation for the hybrid layer not formed in dentin [18].

The authors suggested that in order to have an efficient micromechanical adhesion in collagen fibrils, cements should be able to condition the dental substrate in the shortest time, which require an excellent humidification property to ensure rapid interaction with dentin [18].

The lowest bond strength was found in MaxCem (5.45 MPa) and seT (3.17 MPa), this is due to the different acid monomers in their

compositions such as GPDM in MaxCem and phosphorylated methyl methacrylate in seT, what is the potential and concentration of these functional monomers would be insufficient to promote self-etching in dentin compared to the phosphoric acid esters present in RelyX U100 (10.8 MPa) which had greater bond strength [18].

The work by Costa et al. [16], who evaluated the pH, cohesive strength and micro shear bond strength of two self-adhesive cements RelyX U-100 (3M / ESPE, St. Paul, USA) and seT PP (SDI, Bayswater, Australia in enamel and dentin of bovine incisors.

The bond strength results in dentin were lower than in U- 100 (7.2 MPa) and seT (0.7 MPa) enamel, this can be attributed to the conditions in which cement specimens are produced for the micro test shear and the high viscosity of the cement that makes it difficult to penetrate the dentin. This limitation can be alleviated by exerting pressure during the cementation process, in addition, when the pressure was applied, there was a reduction in porosity at the interface [16].

According to Musashe et al. [19], evaluated the bond strength to the micro-shear bond of RelyX U200 in teeth treated with polyacrylic acid, different substrate conditions and at different storage times. The result presented in dentin was that the control group showed greater bond strength (8.13 MPa) than in the group treated with polyacrylic acid (4.06 MPa). Regarding the condition of the substrate, the wet substrate had a higher bond strength (8.13 MPa) than when dry (4.19 MPa) [19].

Treatment with polyacrylic acid significantly decreased the bond strength. The use of polyacrylic acid is under study according to the literature, as it is possible that this weaker acid provides a degree of demineralization that increases adherence. However, the results of this study showed that the use of 11.5% of this acid resulted in a low bond strength when compared to the control group. Therefore, the removal of the smear layer by the acid promotes demineralization that damages the interaction between the cement and the collagen network on the dentin surface [19].

The bonding mechanism is similar to that of the glass ionomer, therefore, further studies are needed to further understand the use of polyacrylic acid. As demonstrated in the study, self-adhesive cements require moisture to interact with the dental surface to achieve high bond strength values [19].

This information can explain the fact that self-adhesive cements need a means for ionization, in order to start their chemical reaction. As a result, the presence of water on the enamel and dentin surface could create a better ionization medium for cement, which would increase the bonding capacity of cement with enamel or dentin. Therefore, when it is difficult to obtain humidity control in certain procedures, the indication of the use of self-adhesive cements would be the best option, as it is not affected by the humidity on the dentin surface [19].

Post cementation with resin cements can be considered a challenge due to the number of factors that can lead to de-settling, such as lower bond strength, moisture control, solvent evaporation, presence of remnants of chemical agents, adhesion technique, among others [20].

Because they have a different adhesion mechanism than conventional cements, self-adhesive cements can be indicated in these situations because they have less technical sensitivity and the presence of acid functional monomers that allows a secondary reaction between cement and hydroxyapatite through chemical setting [20].

In the study by Pedreira et al. [20] that evaluated the influence of the technique of applying fiberglass posts using self-adhesive resin cements, in the push out test and the presence of bubbles in the thirds of the root. The results showed that the use of a dispenser (Centrix, Shelton, CT, USA) allowed a more homogeneous cement interface, reducing the number of bubbles when compared to the technique

recommended by the manufacturer, which would be the application without the use of a dispenser [20].

The bond strength of self-adhesive cements increased significantly with the use of the dispenser, this may be due to the decrease in viscosity that allowed the monomer diffusion to increase, leading to an increase in the crosslinking rate, especially in the early stages of polymerization. According to the literature, the self-etching ability of these cements to diffuse and demineralize dentin is closely related to the increase in its viscosity, due to an acid-base reaction that occurs after mixing the two pastes [20].

This factor is extremely important, as the cement depends on a great contact with the dental tissue to react with the hydroxyapatite, allowing a better interaction of monomers in dentin, increasing the sealing potential to prevent nanoinfiltration and possibly extending adhesion longevity [20].

Conclusion

The practicality of the luting procedure due to the lower number of steps contributed to make this type of cement an alternative for the professional.

Although their viscosity, composition and setting influence the final result and some results have been low compared to conventional resin cements, it is necessary to think about its applicability in situations that require less of its properties.

This type of cement can be indicated in situations where the use of conventional resin cements presents difficulties, such as when luting post, luting zirconia restorations.

Given the good physical and chemical properties of self-adhesive resin cements, it can be concluded that these materials can perform similarly to conventional resin cement. However, it is necessary to have the knowledge of their chemical and mechanical properties, to use them in each clinical situation.

Further studies are needed to fully assess and understand the clinical performance of cement.

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