Review Article

Orthodontic Cements and Adhesives: A Review

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ABSTRACT:
Bonding of orthodontic brackets to the tooth enamel has been an important issue since the introduction of direct bonding in orthodontics. Dental cements and resins are used intraorally to secure fixed orthodontic devices. Although cements are still used, the popularity of resin and resin-cement hybrid materials is increasing because of their improved physical properties and low solubility in oral fluids. The purpose of this review article is to discuss about the ideal requirements of orthodontic adhesives and to discuss in detail about the various orthodontic adhesives.
Key Words: Adhesives; cements; orthodontics; resins

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Introduction

Orthodontics typically involves the use of braces for aligning teeth. Braces consist of brackets that are bonded to the teeth, and arch wires that are threaded through the brackets. Brackets are bonded to the surface of teeth with orthodontic adhesive. Bonding of orthodontic brackets to the tooth enamel has been an important issue since the introduction of direct bonding in orthodontics. Since then, many new bonding agents have been developed such as composite resins, conventional glass ionomer cements, resin-modified glass-ionomer cements and polyacid modified composites (compomers) with different polymerization mechanism such as chemically, light or dual curing.[1] New orthodontic cements, adhesive resins, and hybrid cement-resin combinations offer improved physical properties and clinical benefits, but there are clear differences in the clinical indications and contraindications for each class of material.[2]

Composite resins are one of the most frequently used adhesives in orthodontic bonding. Although they provide sufficient bonding strength and are easy to handle, they adhere to the tooth enamel only by microretention, require dry field and amount of fluoride release have not been found to be sufficient for anticaries effect. Resin-modified glass ionomer cements as a last generation of glass ionomer cements with improved properties posses some of the good qualities of composite resins as well as some characteristics that make them very desirable for orthodontic bonding like fluoride release properties that can be renewed by local application of fluoride as well as capability of providing satisfactory bond strength to enamel while bonding is performed in presence of moisture. In addition to micromechanical lock with enamel surface irregularities they provide chemical bonding resulting in superior bonding strength.[1] With an understanding of the features, benefits, and limitations, the practitioner can choose the material wisely to obtain optimal results. The purpose of this review article is to discuss about the ideal requirements of orthodontic adhesives and to discuss in detail about the various orthodontic adhesives.

Ideal requirements of orthodontic adhesive

Orthodontic adhesive should be capable of enabling bracket to stay bonded to the enamel for the whole duration of treatment and to permit easy removal of brackets when that is needed without damage to enamel surface and with least discomfort to the patient.[3],[4] The adhesive should be non-irritating to the oral mucosa, allow adequately long working time for positioning brackets while setting quickly enough for patient comfort, provide simple way of application, convenient way of curing, and has fluoride – release potential.[5]

Glass-ionomer cement

Glass ionomer cements were introduced by Wilson and Kent in 1972 as restorative materials, and subsequently became available as luting cements. The first generation of GICs consists of aluminosilicate glass powder and an alkenoate acid liquid, which undergo an acid base reaction when mixed. The second generation GICs incorporated the acid as a freeze-dried powder blended with the glass and are mixed with distilled water.[6] The original glass-ionomer cements (GICs) were water-based materials which set by an acid-base reaction between a polyalkenoic acid and a fluroaluminosilicate glass. Since these were brittle materials, attempts were made to enhance the physical properties by the addition of either metal particles (silver or gold), by a fusion process resulting in a 'cermet' (ceramic-metal), or amalgam alloy particles by a simple addition ('admix').[7]

There are, however, problems associated with the handling properties. Accurate dispensation of the liquid component is difficult, resulting in inaccurate powder:liquid/water ratios, and they are susceptible to moisture contamination during the setting reaction. These can both adversely affect the physical properties of the set material. Whilst the development of encapsulated cement has helped, these are more expensive than hand-mixed cements and wastage is likely.[6]

Zinc polycarboxylate cement

In the quest for an adhesive luting agent that bond strongly to tooth structure, zinc polycarboxylate cements evolved as an adhesive bond to tooth structure.[8] Polycarboxylate cement is the reaction product of zinc oxide and a polycarboxylic acid solution. The carboxyl groups spaced along the polycarboxylic acid chain chelate to calcium in enamel and dentin, result ing in a chemical bond between the cement and the tooth. Polycarboxylate cement was the first chemically adhesive dental cement. As with zinc-phosphate cement, the mixing technique takes time to master because incorporating zinc-oxide powder into the relatively viscous polycarboxylic acid is difficult.[2] These cements were introduced to orthodontics in the early 1970s and offered the advantage of chemical adherence to enamel. However, physical and handling properties were flawed, due to poor tensile bond strength, solubility, viscosity, and short working time.[6]

Zinc-phosphate cement

Zinc phosphate cement is one of the oldest luting cement and has been widely used for band cementation in the last century.[8] Zinc-phosphate cement is the reaction product of zinc oxide and a phosphoric acid solution. When set, zinc-phosphate cement is dimensionally stable with relatively good physical properties, including low solubility in oral fluids. The cement components must be mixed properly to ensure that the acid-base reaction can proceed optimally, resulting in good physical characteristics and minimal effects on oral tissues. Mixing powder/liquid cement products is technique sensitive. Ideally, zinc-phosphate cement should be kept cool during mixing.[2] Zinc phosphate cement was widely used for band cementation for much of the last century. It has high compressive strength, but suffers from low tensile strength and high solubility, resulting in micro-leakage and demineralisation.[6]

Resin Modified Cements

The use of 'metal-reinforced' GICs appears to be diminishing following the introduction of high powder:liquid ratio products. Further modification of water-based ('conventional') GICs took place in the early 1990s by the addition of water-soluble resin, to produce the 'resin-modified' GICs (RM-GICs). The purpose of adding resin was to enhance the physical properties and to reduce the sensitivity to water balance of the conventional GICs.[7] Resin modified glass ionomer cements are hybrid materials of traditional glass ionomer cements with small addition of light curing resin or self curing resin and hence exhibit properties superior to conventional glass ionomer materials. They have the advantage of both adhesion to tooth structure, fluoride release and rapid hardening by visible light.[9],[10]

Capsulation of RMGIC powder and liquid components simplified mixing procedures with a triturator. Although a limited amount of resin monomer can be added to the polyalkenoic acid solution, polymerization of the resin monomers hastens the initial hardening of RMGICs without interfering significantly with the acid-base setting reaction, the fluoride release, or the chelation of carboxyl groups to metal and tooth surfaces. In addition to the chemical bonding of RMGICs, resin monomers penetrate surface irregularities to produce a micromechanical interlock (bond) after polymerization.[2]

Resins

Newman (1965) was the first person to use epoxy resin for bonding stainless steel brackets to enamel. Resin cements are essentially flowable composites of low viscosity. They consist of resin monomers and inert fillers.[8] As with RMGICs, polymerization can be either light activated, chemically activated, or dual cured with both light and chemical activation. Light-activated resin adhesives are always single-component materials stored in opaque packages. Single-component resins are convenient because no mixing is required, thus eliminating technique variables.[2] The chemically cured systems are available as two pastes or as powder and liquid. Several systems use both mechanisms that is chemical cure as well as light cure and are referred as dual cure systems. Resin cements are insoluble in oral fluid. They do not contain any hydro gel and do not show any fluoride release or recharge. Bonding of resins to tooth surface and brackets takes place by mechanical interlock. The bond strength between enamel and brackets depends upon various factors including the type of enamel conditioners, acid concentrations, duration of etching, the bonding agent (primer), the bracket material, base design and the oral environment.[8]

Compomers

Polyacid-modified composite resins, also known as compomers, are single-component systems consisting of aluminosilicate glass in the presence of carboxyl-modified resin monomers and light-activated conventional resin monomers. Although the alkaline glass and acidic carboxyl components are packaged in the same container, allegedly no acid-base setting reaction occurs because water is absent from the composition.[2] This material is moisture sensitive and packed in moisture proof packages. Setting is initiated after light activation (photo polymerization) of the acidic monomers to change to rigid materials. The set material absorbs water from the saliva, allowing a delayed acid-base reaction. This reaction releases fluorides and other remineralising ions from aluminosilicate glass. Because of absence of water in the formula, the material is not self adhesive like the conventional glass ionomer or hybrid glass ionomers. Bonding to tooth surface is by mechanical interlock. Acid etching and other surface treatments are required before bonding, and the bonding surfaces must be dry.[8]

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