Resin-Ionomer and Hybrid-Ionomer Cements: Part I. Comparison of Three Materials for the Treatment of Subgingival Root Lesions

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The purpose of this study was to compare the characteristics of three different restorative materials for the treatment of subgingival root lesions. Eighteen recently extracted teeth were used to test the depth of cure and the surface characteristics of these products. Although none of the materials tested exhibited all of the author's ideal characteristics for a subgingival restoration, one restorative material displayed the most favorable result. (Int J Periodont Rest Dent 1996;16:595-601.)

Since their introduction to the dental profession by Wilson and Kent in 1972,1 glass-ionomer materials have increasingly been used in restorations, cementation, cavity lining and reaming, post-and-core build-up, and preventive applications.2 In a 1990 survey of Iowa general dentists, 85% of the respondents claimed to use glass-ionomer cements in their practices for the placement of liner and bases and in crown cementation.3

The original ion-leachable glasses were based on a 
\( \text{SiO}_2-\text{AlO}_3-\text{CaF}_2-\text{AIPO}_3-\text{Na}_2\text{AlF}_6 \) composition in combination with aqueous polyacrylic acid.2 These traditional materials demonstrated biocompatibility and chemical adherence to tooth structure, as well as the ability to produce cariostasis through the slow release of fluoride.4 However, the original formulations were brittle, produced relatively low bond strengths, and demonstrated microleakage at the glass-ionomer and

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cavity-wall interface. Post-operative sensitivity related to glass-ionomer luting materials was attributed to their low pH.

In an attempt to resolve the problems associated with glass-ionomer cements, a modification was made in the original formulation, in which some of the water content was replaced by a water-soluble monomer system containing hydroxyethyl methacrylate (HEMA) capable of ambient free-radical polymerization. Thus, materials that demonstrate a dual-setting mechanism that involves the acid-base reaction of the polyacrylic with the glass and the polymerization reaction have evolved. In addition, light-curing systems have been developed in which the powder component is primarily composed of a fluoroolaminoperoxide component containing a photoinitiator and the liquid component is an aqueous solution of a polyacrylic acid copolymer with pendant methacrylate groups, HEMA, and a photoinitiator. These modified formulations have been categorized as hybrid- or resin-modified glass-ionomer cements.

More recently, modifications have produced materials, called resin-ionomer cements or compomers, that focus on the use of functional nonaqueous monomers and prepolymer in conjunction with inert inorganic and/or organic fillers in combination with photoinitiators and glass-powder formulations. These materials set in two stages: (1) light activation, which allows the polymerizable molecules to interconnect; and (2) after absorbing water from the moist environment of the mouth, an ionic acid-base reaction takes place that crosslinks with the established matrix.

These newer materials possess the following characteristics and advantages: (1) insolubility in oral fluids; (2) increased adhesion to tooth structure and other dental substrates; (3) dual-cure capabilities; (4) low cure shrinkage; (5) low coefficient of thermal expansion; (6) radiopacity; (7) fluoride release; and (8) biocompatibility. Therefore, their potential clinical applications have included:

1. Routine restoration of anterior teeth
2. Restoration of erosion lesions in the geriatric patient
3. All-purpose cementation of fixed partial prosthesis and resin-bonded retainers
4. Porcelain repairs
5. Bonding of amalgam restorations
6. As post-and-core build-up
7. As a pit and fissure sealant
8. As a pediatric restorative
On-going in vitro and in vivo research involving 25 patients has also indicated that hybrid- and resin-ionomer cements may be used as subgingival restoratives to treat teeth and conditions previously thought to be unrestorable by many dentists. Such applications include the restoration of lesions that occur near or apical to the gingival sulcus, i.e., fractured roots, areas of root resorption, and deep carious root lesions.

Results from this research will be presented in three papers: Part I: Human Clinical and Histologic Wound Healing Responses in Specific Periodontal Lesions; and Resin-Ionomer and Hybrid-Ionomer Cements: Human Clinical and Histologic Wound Healing in Maxillary and Mandibular Furcations. The purpose of Part I is to compare the characteristics of three different ionomer-like materials for the treatment of subgingival root lesions.

Method and materials

Two resin-ionomer restorative materials, Dyract (restorative A, DeTrey/Dentsply) and Geristore (restorative B, DenMat), and one hybrid-ionomer restorative material, Photac-Fil (restorative C, ESPE Premier), were used to restore the dental lesions. All materials were used according to their manufacturers' instructions.

Radiopacity of the three restorative materials was evaluated in vivo by placing the restorations subgingivally and using radiographs to evaluate the presence or absence of radiopacity. Three subgingival restorations were made with each material.

Nine recently extracted human teeth were randomly divided into three groups to evaluate the surface hardness of the three different materials by hand and ultrasonic instrumentation. Lesions 2.0 mm deep were prepared in these teeth 3 to 6 mm apical to the cementoenamel junction. The lesions were restored by group and placed in physiologic saline for 24 hours. Each specimen was mounted in an acrylic block and sectioned with a diamond blade for macroscopic evaluation.

An additional nine recently extracted human molar teeth were randomly divided into three groups to evaluate the surface hardness of the three different materials by hand and ultrasonic instrumentation. Lesions 2.0 mm deep were prepared in these teeth 3 to 6 mm apical to the cementoenamel junction. The lesions were restored by group and placed in physiologic saline for 24 hours. Each group was embedded in acrylic blocks, and the restoration was curetted with 36 strokes with either a sharp curette or an ultrasonic instrument. Subsequent to the evaluation of surface hardness, each acrylic block was sectioned for microscopic study of the adaptation of the restorative material to the dentin surface.
Results

A representative photomicrograph of restorative C (Fig 1) showed this material to be in close adaptation to the dentin surface without any bonding system. A representative photomicrograph of restorative B (Fig 2) demonstrated close adaption to primed dentin surfaces. A representative photomicrograph of restorative A showed that the material had closely adapted to the primer/adhesive (PA) layer; however, it was loosely adapted to the dentin (Fig 3).

Further differences between the materials may be discerned. Restorative B and restorative A were radiopaque materials, in contrast to restorative C (Figs 4a and 4b). Restorative B and restorative C were set by dual-cure mechanisms, but restorative A was set only by light activation. Cross sections of the teeth with 5.0-mm-deep cavity preparations revealed that only restorative B cured the entire 5.0 mm (Fig 5). The light-activated restorative A was cured only 3.2 mm into the preparation, which was consistent with the manufacturer’s recommendations. Restorative C samples only exhibited a surface cure.

Finally, the resin-ionomer restorative materials (A and B) demonstrated a significantly greater ability to withstand the forces associated with scaling and root planing (Fig 6). The restorative C samples exhibited marginal brittleness and flaking when scaled with sharp curettes and ultrasonic tips, and demonstrated less surface hardness compared to restoratives A and B.
Fig 4a  Clinical photograph of two central incisors in which subgingival restorations were placed near the alveolar crest (arrows). The maxillary left central incisor was restored with radiolucent restorative C, and the right central incisor was restored with radiopaque restorative B.

Fig 4b  Radiograph of the two central incisors in Fig 4a. Note that it is impossible to evaluate the integrity of the radiolucent hybrid glass-ionomer restorative in the left central incisor compared to the radiopaque resin-ionomer material in the right central incisor.

Fig 5  Photograph of a cross section of a tooth that had two 5.0-mm-deep cavity preparations restored with restorative A (RA) and restorative B (RB). The light-activated restorative A cured to a depth of 3.2 mm, but the dual-cured restorative B set to the entire depth.

Fig 6  Photograph of a gold crown with margins placed in resin-ionomer cement (RI). A sharp 4R curette and an ultrasonic instrument were used to test the surface hardness of the resin-ionomer and the integrity of the crown margin. Note that the margin was opened slightly after 36 vertical strokes with a sharp curette (C), and the marginal integrity was preserved after 36 vertical strokes (S) with a Slimline (Dentsply) ultrasonic insert used on an ultrasonic scaler with medium power.
Discussion

Materials used to restore subgingival lesions should include, but not be limited to the following properties: (1) biocompatibility, (2) a dual-cure set, (3) adhesive-ness, (4) fluoride release, (5) radiopacity, (6) compactness, (7) surface hardness, (8) insolubility in oral fluids, (9) absence of microleakage, (10) low coefficient of thermal expansion, and (11) low cure shrinkage. In addition, it should be noted that subgingival restorative procedures are very technique sensitive. Parts II and III will address the technical procedures and wound healing results.

The materials used in this study were recommended by their manufacturers for use as restoratives in Class V cavities and cervical abrasion/erosion lesions, in Class III cavities, and for restoring Class I and II cavities in deciduous molars. In addition, restorative B demonstrated adhesiveness to substrates other than tooth structure, including porcelain, nonprecious and precious metals, and amalgam. Restorative C demonstrated adhesiveness to dentin; however, its bond values were significantly lower when compared to restoratives B and A.

Glass-ionomer materials have shown favorable biocompatibility with bone. In part, this biocompatibility has been attributed to the negligible exothermic reaction on setting, the rapid rise in pH as the material hardens, and substances (fluoride) that are leached from the set cement and provide a beneficial effect for the tissue in proximity to the cement. Fluoride release may also result in antimicrobial activity and an elevation in the acid-resistance of tooth structure, and may possibly alter the nature of the plaque surrounding the restoration. Although the materials used were not traditional glass-ionomer cements, they appeared to possess the above characteristics.

The issue of radiopacity becomes a concern, especially when one places restorations subgingivally. A radiopaque material is essential for observation to assess the effects of clinical wound healing in a longitudinal fashion. A radiolucent material such as restorative C makes this impossible.

One of the most important characteristics of a biocompatible subgingival restorative material is its ability to set in a true dual-cure fashion. This becomes imperative as it is often difficult to place a light source and impossible to judge the actual depth of the defect to be restored. Materials that set by light activation require only incremental layering if the depth of placement for the restorative is more than 2.5 to 3.0 mm. In such situations, incremental placement results in increased working times that can affect the control of hemostasis. Restorative C cannot undergo a “dark set.” Thus, in darker areas or in areas not accessible to light, the material does not undergo a true dual-cure set. This helps to explain the noted lack of set in the sections of restorative C when depth of cure was compared. These sections also indicated that restorative A could only set to a depth of 3.2 mm during light activation; the remaining material remained unset (see Fig 5). This study indicated that restorative B was the only true dual-cure material of those tested.

The greater compactness of the resin-ionomer materials appears to be directly proportional to the solid loading fillers that can be found in these products compared to the mainly glass components of restorative C. Thus, the surface hardness of the resin-ionomer materials allows them to withstand abuse from scaling and root planing better than the hybrid-ionomer material, especially at restorative root margins (see Fig 6).
Conclusions

1. The author proposes that the ideal characteristics of a subgingival restorative material include, but are not limited to: biocompatibility, dual-cure set, adhesiveness, fluoride release, radiopacity, compactness, surface hardness, insolubility in oral fluids, absence of microleakage, a low coefficient of thermal expansion, and low cure shrinkage.

2. All the materials used in this study demonstrated biocompatibility with the adjacent soft tissues.

3. Although none of the materials tested exhibited all of the author's ideal criteria of a subgingival restorative material, Geristore (a resin-ionomer restorative material) was the most favorable.

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References

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