Clinical placement of modern glass-ionomer cements

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The main advantages of glass-ionomer cement are its ionic exchange with dentin and enamel and its continuous fluoride release, which acts as an effective anticariogenic agent. The new dual-curing (light-activated) cements have enhanced physical properties and excellent esthetics, so the situations in which they can be placed as a complete restoration are greatly increased. If the occlusal load is too great to use glass-ionomer cement alone, the dual-curing cements are ideal for the lamination technique, in which the cement is used as a dentinal substitute and is covered with composite resin. This paper discusses the clinical placement techniques required to ensure success with either technique. (Quintessence Int 1993;24:99-107.)

Introduction

The recent advent of dual-curing (light-activated) glass-ionomer cements has encouraged the profession to rethink the uses of these materials. The first glass-ionomer material was introduced in 1976, and the response was briefly enthusiastic. However, the material was perceived to have problems in clinical placement, and enthusiasm waned. In some countries this class of cement is still used because of its obvious advantages. A number of manufacturers have continued to modify the original formula to overcome the problems, and the materials should be recognized as a valuable adjunct to preventive and restorative dentistry.

This paper details techniques for successful clinical placement of both the original autocuring and the new dual-curing cements, taking into account the strengths and weaknesses of both. Their main limitation is their lack of physical strength, but the problems arising from this can be minimized if they are always used at a high powder-liquid ratio and are handled properly. An advantage is their ionic exchange with underlying tooth structure, which depends on proper conditioning of the cavity. The continuous fluoride release is most valuable.

The new dual-curing cements do not require protection following placement, because they are immediately resistant to water uptake after light activation. However, the auto-curing cements are useful where access for the curing light is limited.

The ability to combine glass-ionomer cement as a dentinal substitute with composite resin as an enamel replacement allows the "monolithic" reconstruction of a tooth, which is most valuable in esthetic dentistry.

The maintenance of esthetics has become an important responsibility over recent years for the restorative dentist. The days of battling ongoing rampant caries in the majority of patients have gone, and the profession is essentially left with two problems to deal with: (1) in spite of our knowledge of prevention and the almost universal presence of fluoride, some patients still present with new lesions representing a state of active caries; and (2) there remains a large segment of the population whose teeth have already been restored according to the principles first espoused by Black and whose restorations have undergone the inevitable predictable breakdown (recurrent caries, lost cusps, or broken restorations). Both of these groups of patients are now likely to seek esthetic restorations. The first group, with early lesions, presents a relatively minor

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problem, assuming that they will undertake some positive preventive measures to protect themselves from further caries. The second group offers a more difficult problem, in as much as these patients will almost inevitably have lost so much natural tooth structure that traditional repair and replacement with long-lasting restorations is economically and clinically difficult.

The development of new restorative materials in the last two decades has been dictated to a large extent by this dilemma. While great progress has been made in the fulfillment of the dream, economic, long-term restoration of extensive lesions is still some distance away.

The simplest and most economic materials are the direct restoratives, composite resin and glass-ionomer cement. Both are esthetically acceptable and work effectively alone or in combination. Composite resin has, arguably, better esthetics and superior physical properties, but glass-ionomer cement has an ionic exchange with tooth structure as protection against microleakage and a fluoride release that is the best protection available against recurrent caries.

It is not difficult to unite the two materials, and the result can be the closest approach yet available for a complete monolithic restoration. Glass-ionomer cement bonds to the dentin through an ion exchange. Composite resin attaches micromechanically to an autocuring cement, or, alternatively, chemically to a dual-curing cement. Finally the composite resin develops a micro-mechanical union with the enamel. If both the materials are handled correctly, with a full understanding of the properties and requirements of each, the result will be an economic, esthetic restoration with a reasonable expectation of longevity.

The clinical and physical properties of composite resin have been extensively researched over the last 20 years, and the material has been constantly upgraded. Composite resin is capable of withstanding reasonable occlusal stress, and the wear factor approaches that of amalgam. However there is still considerable doubt about its ability to adhere to dentin over long periods of time, it has no fluoride release, and it shows a relatively large immediate dimensional change when cured, particularly when curing is light activated.

This paper will deal with glass-ionomer cement and the part it can play in the provision of esthetic, long-lasting restorations both alone and in combination with composite resin. Success with these cements revolves around several important factors:

1. Glass-ionomer cement adheres to underlying tooth structure through an ionic exchange and there is no microleakage between the cement and the tooth structure.¹
2. The strength of adhesion is directly proportional to the tensile strength of the cement, because failure is always cohesive in the cement and not at the interface with the tooth.²
3. The stronger the cement, the better the adhesion; the higher the powder-liquid ratio the better the adhesion; and dual-curing (light-activated) glass-ionomer cements have better adhesion because they have higher tensile strength.³
4. The ionic exchange between cement and tooth structure will occur more easily on a clean surface and in the absence of contaminants. Therefore the cavity should be conditioned initially with 10% polyacrylic acid for 10 seconds, washed thoroughly, and dried lightly.⁴
5. Fluoride is released from the glass powder at the time of mixing and lies free within the matrix. It can therefore be released without affecting the physical properties of the cement. It can also be taken up into the cement and released again. The cement will act as a fluoride reservoir over long periods of time.⁵
6. The autocuring Type II.1 esthetic restorative cement is now the only cement that is susceptible to water uptake immediately after placement. To obtain optimal esthetic results, it is necessary to seal these restorations, as soon as the cement is set, with a low-viscosity, single-component, light-activated resin enamel bonding agent, which, after activation, will remain in place for at least 24 hours.⁶
7. The dual-curing Type II.1 restorative cement does not require sealing because it is resistant to water uptake as soon it is light activated.
8. All autocuring cements remain susceptible to dehydration for some time after placement, so they should not be unduly challenged by excessive dehydration.⁷
9. The dual-curing cements are relatively resistant to dehydration immediately after light activation.
10. The esthetic results of glass-ionomer cement restorations, whether autocured or dual-cured, should not be judged for at least 1 week, because the restorations continue to mature, and translucency and physical properties will improve.⁸
Principles of placement

The main limitation of the glass-ionomer cements is their relative lack of strength. They should not be subject to undue occlusal load unless they are well supported by surrounding tooth structure. However, lamination with composite resin will offer sufficient support and protection so that glass-ionomer cements can be used in a variety of situations for the esthetic restoration of both carious and erosion lesions. When occlusal load is not a factor, such as in Class V carious and erosion lesions or in Class III restorations, lamination is not necessary and the cement makes an excellent restoration by itself. The autocuring cements can develop sufficient translucency to be satisfactory in most cases, but the newer dual-curing cements have an immediate translucency that is equivalent to that of composite resin. Therefore glass-ionomer cement is the material of choice for all cavities not subject to occlusal load.

If lamination is desirable for either esthetics or strength, the cement should be placed first, using the strongest variety possible. If optimal advantage is to be gained from its desirable properties, the cement should be mixed at a high powder-liquid ratio and the cavity should be conditioned with 10% polyacrylic acid for 10 seconds. There will now be an ionic exchange with the dentin and optimum tensile strength in the cement. The cement can now be reduced to allow lamination for protection. The first part of the restoration can now be regarded as a dentinal substitute and can remain exposed to the oral environment on proximal surfaces and at gingival margins, where the fluoride release is most beneficial.

Because the micromechanical union between enamel and composite resin is the strongest adhesion available in the oral cavity, the laminate should be regarded as an enamel substitute. The cement should be reduced to expose all available enamel and provide sufficient room for a reasonable thickness of resin. Both the enamel and the cement should be etched for 15 seconds to develop the micromechanical interlock. A low-viscosity enamel bonding resin should be applied to ensure the optimal union. Etching is not essential for union with the dual-curing cements, because there are sufficient free radicals left in the resin matrix of the cement to develop a sound union; if etchant is placed on the cement, however, the etchant will produce a clean surface, free of smear layer, and will do no harm.

Use of as little composite resin as possible to restore the cavity is desirable, for an overall reduction in the total volumetric shrinkage of the resin during the setting reaction; this will reduce the stress on the remaining tooth structure. The cement is also subject to a setting shrinkage, but this is spread over a much greater period of time and is less than half that of the resin. The lower physical properties in the cement are of little significance, because the occlusal load is dissipated through the resin laminate and reduced by a factor of ten before it reaches the cement (Gasser O, personal communication, 1988). However, composite resin is rather flexible, so it requires a reasonable bulk to prevent stress fracture particularly in areas of heavy load.

Clinical placement

The following routines should be followed for the clinical placement of glass-ionomer cement when it is being utilized for the maintenance of esthetics.

Class V cavities and erosion lesions

Dual-curing Type II.1 cement should be used (Figs 1 to 6), unless light curing is not available or the position of the lesion precludes the correct placement of the light.

Capsulated cements are preferable to ensure a standard result. If the cement is handmixed, the correct powder-liquid ratio must be provided, because the ultimate tensile strength, and therefore the strength of adhesion, depend on the strength of the cement. It is mixed quickly and the powder is gently folded into the liquid with minimum spatulation to merely wet the surface of each particle. The cement should be ready for placement within 30 seconds.

For an erosion lesion, the area is cleaned lightly with a slurry of pumice and water on a rubber cup and rinsed clean. For an erosion lesion or a prepared cavity, the area is conditioned with 10% polyacrylic acid for 10 seconds, washed well, and dried lightly.

If it is hand mixed, the cement is transferred to a Centrix syringe to ensure positive placement and adaptation to the cavity floor. The use of a matrix is not mandatory but will enhance placement and development of anatomy and contour. Translucent matrices (Hawe-Neos) are available for the dual-curing cements, and soft tin matrices are suitable for the autocuring cements.

Dual-curing cements should be light activated for 20 seconds with the matrix in place and for a further 20 seconds immediately after removal of the matrix. Generally, while the matrix is in position, it is not possible
Fig 1  The extensive Class V erosion lesions on the buccal aspect of the maxillary right canine and first premolar are to be restored with a dual-curing glass-ionomer cement.

Fig 2  The lesions are lightly scrubbed with a pumice and water slurry and washed clean.

Fig 3  The dentin is conditioned with 10% polyacrylic acid for 10 seconds and washed again. A slight gingival hemorrhage has been controlled with trichloracetic acid.

Fig 4  The translucent matrix is tested to see that it fits, before the cement is mixed.

Fig 5  After 40 seconds of light curing, the cement is contoured and polished with very fine diamonds under air-water spray.

Fig 6  Finished restorations after 1 week.
to position the light close to the cement, and the matrix holder may cast a shadow. As it is impossible to overcure any light-curing material, it is wise to apply the light for at least a short period after matrix removal.

Autocuring cement will be set approximately 4 minutes after the start of mix. The texture of the excess cement around the matrix is tested for degree of set. The matrix is not removed until the cement is quite hard and brittle. If a matrix is not being used, the cement is covered, as it begins to harden, with a generous layer of varnish to prevent dehydration.

Dual-curing cement requires no protection after placement because it is resistant to water uptake immediately. However, it will dehydrate slowly if exposed to air for longer than 10 to 15 minutes.

Autocuring cement is subject to water uptake and water loss for some time after setting and must be protected from the oral environment immediately. The manufacturers provide a varnish for this purpose, but the most effective sealant is a very low-viscosity, single-component, light-activated enamel-resin bonding agent, such as Ketac Glaze (ESPE). After the matrix is removed and before the cement is trimmed, the restoration is covered with a generous layer of the sealant, and the curing light is activated.

Dual-curing cement can be contoured and polished, immediately after removal of the matrix, with very fine polishing diamonds under air-water spray at intermediate-high speed. The Two Striper polishing diamond series (Abrasive Technology) is ideal for this purpose, but a very light touch is necessary to avoid gouging the cement. A final finish can be achieved with Sof-Lex Disks (3M Dental) if required.

Auto-curing cements can be contoured and polished with the same technique, but the procedure should be delayed for about 7 days to allow full maturation of the cement. At this time the development of a satisfactory color match can be confirmed and it can be decided whether lamination is required.

**Class IV restorations**

Dual-curing cement should be used because it has superior esthetics and can be cut back and modified immediately after placement. Use of a capsulated variety is preferable. The cement should be dispensed and mixed with care if handmixing is necessary.

The prepared cavity is conditioned with 10% polyacrylic acid for 10 seconds, washed thoroughly, and dried lightly.

A short length of Mylar strip is positioned interproximally and wedged in place. The cement is inserted with a syringe to ensure positive placement into the depths of the cavity and to minimize porosity. The cavity should be filled generously and all the dentin should be well covered.

The Mylar strip is wrapped carefully around interproximally to achieve an acceptable proximal contour at the gingival margin. Light is applied for 20 seconds from both the labial and the lingual aspects to ensure adequate cure.

The preparation is redesigned in the cement with fine diamond burs under air-water spray at intermediate-high speed. All enamel walls are exposed, but if the gingival enamel is weak or missing a layer of at least 1 mm of cement should be left along the entire gingival margin. The enamel margins are beveled, particularly on the labial and lingual aspects, to ensure an optimal union between the enamel and the composite resin lamination.

The enamel walls are etched for at least 15 seconds. It is not necessary to etch the cement, but if etchant is inadvertently placed on it there will be no deleterious effect. The enamel is washed thoroughly and dried well. It is essential to achieve the usual matte appearance in the enamel to obtain proper adhesion of the resin.

A thin coat of a low-viscosity intermediate resin-enamel bond is always applied to both the cement and the enamel to ensure the best union between the two. The excess bonding agent is blown off and light activated before the composite resin is placed. The composite resin is placed incrementally, beginning at the gingival wall and extending up the lingual wall. Each increment is cured adequately to obtain complete shrinkage before the next increment is placed. A hybrid resin is used for the entire lingual surface to the incisal edge. A veneer of microfilled resin is added on the labial surface to enhance translucency and surface finish.

The restoration is mostly contoured during placement, but final anatomy can be developed with the very fine Two Striper diamond polishing burs under air-water spray at intermediate-high speed. Care must be taken not to gouge the glass-ionomer cement, which is not as hard as the resin and can therefore be easily damaged.
Fig 7  Class III root caries lesion on the distal aspect of the maxillary right central incisor.

Fig 8  Completed cavity under rubber dam.

Fig 9  Because the cavity extends to within 0.5 mm of the pulp, a small area of a fast-setting calcium hydroxide liner is placed over the pulp.

Fig 10  The cavity is conditioned prior to placement of the glass-ionomer cement.

Fig 11  The completed restoration is contoured and polished before the dam is removed.
Class III restorations

All Class III cavities are suitable for restoration with dual-curing glass-ionomer cement (Figs 7 to 11). The translucency and esthetics are adequate and the physical properties are sufficient, because normally there is adequate support from remaining tooth structure. The ionic bonding to tooth structure and the fluoride release make glass-ionomer cement the ideal restorative material.

The principles of placement are the same as for the Class V restoration. The cavity is conditioned to remove the smear layer, and a transparent Mylar strip is used as a matrix and wedged as required. The cement is placed with a syringe and light activated from both the labial and lingual aspects for a minimum of 20 seconds for each side. Contouring and polishing should be minimal and can be carried out immediately.

Class II restorations

The selection of the appropriate material and the method of restoration will depend on whether a new carious lesion is to be restored or an old restoration is to be replaced. Ideally a new lesion should be restored with a minimal cavity design, or Class II* tunnel, which will retain the proximal marginal ridge and most of the proximal surface anatomy. The dual-curing cement is ideal for such a restoration because of its easy handling and radiopacity. However, if placement of the curing light is difficult, it may be necessary to use an autoturing cement.

If the proximal surface is already deeply undermined or removed (as when an old restoration is being replaced), then a conventional approach is required. Again the use of a dual-curing glass-ionomer cement is recommended, because of its radiopacity and easy handling; it will have to be laminated with composite resin to accept the occlusal load.

Class II tunnel restoration. This cavity is designed to deal with the early proximal lesion in which the dentin is just involved, the proximal enamel is relatively sound, and the marginal ridge is intact. The dentinal lesion is removed with a small tapered diamond at intermediate-high-speed under air-water spray. The occlusal enamel is entered just medial to the marginal ridge and the tip of the diamond is aimed toward the lesion. Tactile sense normally is sufficient to indicate when the lesion has been entered, but magnification and good illumination are mandatory. After the various lesion is identified, the access cavity is opened both buccally and lingually along the inside of the marginal ridge; the ridge should not be weakened any more than is essential. The result will be a somewhat triangular access cavity with a reasonable view of the lesion. This can now be removed with small round burs. If the proximal enamel is only demineralized and not carious, it is left intact.

The cavity is conditioned with 10% polyacrylic acid for 10 seconds, washed and dried lightly. A short piece of polyester matrix strip is placed between the teeth and wedged lightly into place.

A dual-curing glass-ionomer cement is placed, through a syringe, into the depths of the cavity. If the cavity is very small, the needle tip on the Centrix syringe is used so that air will not be entrapped within the cavity. The cement is cured from the buccal, lingual, and occlusal aspects for 20 seconds in each position to ensure that all the cement is activated. The autoturing component of the dual-curing cements has physical properties close to those of the light-curing section.

In most cases, because the cement is surrounded and well supported by the remaining enamel, the glass-ionomer cement is sufficient alone. However, if there is any doubt about the occlusal enamel, the cement can be reduced 1 to 2 mm and laminated with composite resin as described previously.

It is generally unnecessary to polish the interproximal surface. If there is any doubt about the presence of an overhang or excess material, a fine polishing strip is passed interproximally once or twice. The occlusal surface can be contoured with the very fine Two Striper polishing diamonds under air-water spray at intermediate-high speed.

Conventional Class II restoration. If the marginal ridge is grossly undermined and weakened or if an old restoration is to be replaced (Figs 12 to 14), glass-ionomer cement should be used as a dentinal replacement and composite resin laminated over the cement to restore the enamel. The same principles apply as for the Class IV restoration. The most important requirement is for the restoration to have adequate strength to withstand occlusal stress and the rebuilding should be designed to accommodate this.

Because of its greater tensile strength, the autoturing Type II.I restorative esthetic cement is the material of choice. In the past, different Type III lining cements have been used, but in most cases they were mixed at a low powder-liquid ratio and therefore lacked tensile strength. Many of them, including a number of
the dual-curing liners, were also unstable in the presence of water and were therefore likely to take up excessive water and disintegrate over time. The cement was often placed in thin layers, in the manner of linings under amalgam restorations, leaving the cement weaker and susceptible to being lifted off the dentin by the setting shrinkage of the composite resin. The placement of an autocuring restorative cement in bulk to a position just below the contact area in this type of cavity ensures optimal adhesion as well as adequate support for the resin laminate.

The enamel outline of the cavity is kept to a minimum, but all softened enamel is removed. It is not necessary to remove all unsupported enamel or to extend the cavity beyond contact with the adjacent tooth. Undercuts and mechanical interlocks are not required, and pins are contraindicated. The cavity is conditioned with 10% polyacrylic acid as described previously.

A short length of Mylar strip is positioned interproximally and wedged into place. The glass-ionomer cement is placed with a syringe to ensure adequate placement into the depths of the cavity; a needle point tip is used on the syringe if required. The cement is built up incrementally in layers of 3 to 4 mm and each layer is adequately cured. The cavity is overfilled so that the cement can be contoured to the required design.

The cement can now be regarded as a dentinal substitute, and it is only necessary to make room for a sufficient thickness of composite resin to ensure that the resin will be an adequate replacement for the enamel. A small fine-grained diamond tapered cylinder is used under air-water spray to refine the cavity in the cement to meet these requirements. All available enamel walls are exposed and beveled as required. Sufficient cement is removed from the proximal boxes to allow the contact areas to be built up in composite resin, but at least 1 to 2 mm of cement is left exposed at the gingival wall. Retentive undercuts and interlocks are not necessary.

The enamel walls are etched for at least 15 seconds, washed, and dried very thoroughly. It is not necessary to etch the cement, but etchant will not harm the cement. A thin layer of a very low-viscosity resin-enamel bonding agent is placed. The excess is blown off, but the cement must also be covered. The bonding agent is cured and the cavity is ready for the final placement of the matrix and incremental placement of the composite resin. The resin is placed incrementally to
minimize setting shrinkage. The restoration is over-
built to allow contouring during the development of
the occlusion.

The restoration is contoured and polished with Two
Striper fine polishing diamonds and finished with flexi-
able disks. Proper occlusal contact must be maintained
with the opposing arch.

Conclusions

Modern glass-ionomer cements can play an important
part in the development of long-lasting, esthetic resto-
raions. To some degree, old methods must be aban-
doncd and new systems introduced. For the last two
decades, the dental profession has been seeking a
sound method of restoring Class V and erosion lesions
with a material that is both esthetic and retentive.
Glass-ionomer cements have a very high rate of reten-
tion, but their esthetic results were originally not as
reliable as those of composite resin. Now dual-curing
cements have successfully challenged the problem of
esthetics, and their retention is better than that of
curing cements because dual-curing cements have
greater tensile strength.

The improved properties of dual-curing cements
open the way to a great advance in the so-called
sandwich technique and eliminate the problems of
conventional lining methods. The old-style linings,
placed in small increments and thin sections, were de-
veloped for amalgam restorations and not composite
resin restorations, where strength and retention are an
integral part of developing a monolithic rebuild of a
broken down or carious tooth.

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