Artificial caries in primary and permanent teeth adjacent to composite resin and glass ionomer cement restorations

M. Varpio, DDS, BA J.G. Norén, DPh, BSc

Introduction

In search of restorative materials other than amalgam, both composite resin and glass ionomer cement (GPA) have been employed, but both have drawbacks.

Composite resin restorations in Class 2 cavities in the primary dentition have been studied in retrieved teeth after clinical function of at least one year. Dye penetration was a frequent finding at the cervical margins[1] as well as recurrent caries and bacteria subjacent to the fillings.[2]

Studies on marginal leakage of GPA cements after clinical use have not been published, but in vitro tests have shown that Class 2 cavities in primary and permanent teeth isolated with GPA cement exhibited significantly less leakage than those isolated with calcium hydroxide.[3]

In vitro tests of GPA restorations in acidified medium have shown significantly less demineralization in permanent teeth around GPA than amalgam or composite.[4] Similar experiments on recurrent caries in the primary teeth with histologic properties in the enamel dissimilar to those of the permanent teeth have not been reported.

The aim of this study was to compare composite resin and GPA cement restorations in primary and young permanent teeth exposed to the same acidulated artificial caries conditions.

Methods and materials

Caries-free permanent premolars and third molars extracted for orthodontic indications and primary molars extracted for pulpal complications were used for the investigation and stored in 1% thymol solution until processed.

Class V cavities were prepared on either buccal or lingual caries-free surfaces with a #3 inverted cone bur under water irrigation. The cavity was uniform according to the bur size, surrounded by enamel, and extended into the dentin. Cavities intended for a GPA cement filling were prepared with a butt joint while cavities designed for composite resin filling were beveled. After the preparation, specimens were examined under a light microscope at 32x magnification for defects in the enamel, and all preparations showing fracture lines or cracks in the enamel border were discarded. The specimens were then embedded in an epoxy resin leaving the cavity and 2 mm of the surrounding enamel free.

No lining or isolating cement was used under either GPA cement or composite resin. The materials were handled according to the manufacturer's recommendations. The GPA cement (ESPE Ketac-Fil,® Seefeld/Oberbay, Germany) was applied after cavity pretreatment with conditioner (ESPE Ketac Conditioner®) for 10 sec, rinsed with water for 30 sec, and air dried. The GPA filling was then covered with a matrix (Cervical Matrices® Nr 718C, Hawe-Neos Dental, Gentilino, Switzerland) for 5 min. The matrix was removed and the restoration trimmed with a scalpel and covered with a varnish (ESPE Varnish®). Fifteen minutes after the start of the mixing of the GPA cement, the tooth specimen was immersed in test solution or water.

For the composite resin restorations, a hybrid composite (Prismafil Compules®, Dentsply Limited, De Trey Division, Weybridge, Surrey, GB) was used, the enamel bevel was etched with gel (De Trey Etch Gel®) for 60 sec, rinsed with water for another 60 sec, air dried and covered with bonding resin (Prisma Universal Bond®). Composite resin was inserted from a capsule and the filling trimmed before curing with visible light for 20 sec. After 5 min, the boundaries of the restoration were re-etched for 30 sec, rinsed for another 30 sec, dried and covered with bonding resin, and cured with visible light for 20 sec. After 5 min, the tooth specimen was placed in water or in the test solution.

In all, 60 specimens were prepared—30 in primary and 30 in permanent teeth. In each tooth category, 15 cavities were filled with composite resin and 15 with GPA cement. Twenty restorations (five GPA in primary, five GPA in permanent teeth, five composite resin in primary, and five composite resin in permanent teeth) were placed in distilled water as controls and the remaining 40 in a receptacle with the test solution for 2 weeks.

The test solution was made up according to Theuns, et al.,[5] consisting of 8.5 mmol/l of calcium monophosphate in a 61 mmol/l solution of acetic acid. Sodium hydroxide or hydrochloric acid was used to adjust the solution to a pH of 4.0.

After 2 weeks in the acetic acid solution, the teeth were rinsed and stored together in distilled water. A mean of six serial sagittal undemineralized sections,

Table. The number of primary and permanent teeth with cavity wall lesions adjacent to composite resin (C) and glass polyalkeonate cement (GPA)

	Primary Teeth	*Permanent Teeth*	*Primary Teeth*	*Permanent Teeth*	*Total*
Number of fillings	C	C•	GPA•	GPA	37
Cavities with wall lesions	7	2	0	2	11
Cavities without wall lesions	3	7	8	8	26
Total	10	9•	8•	10	37

• One C and two GPA fillings could not be assessed.

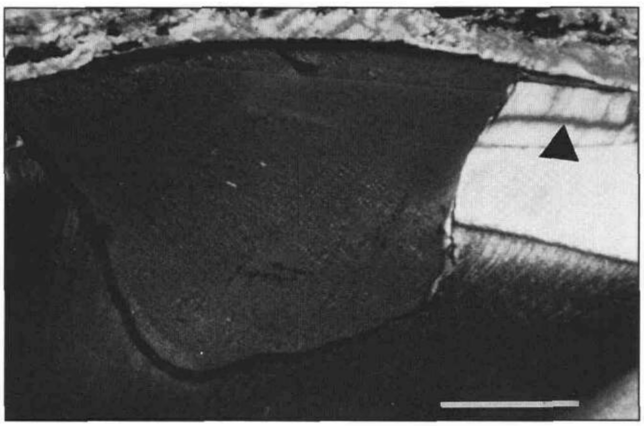

Fig 1. Ground section of a primary tooth with a composite resin restoration seen dry in air in polarized light. An enamel lesion is seen on the incisal border of the filling (Arrow).

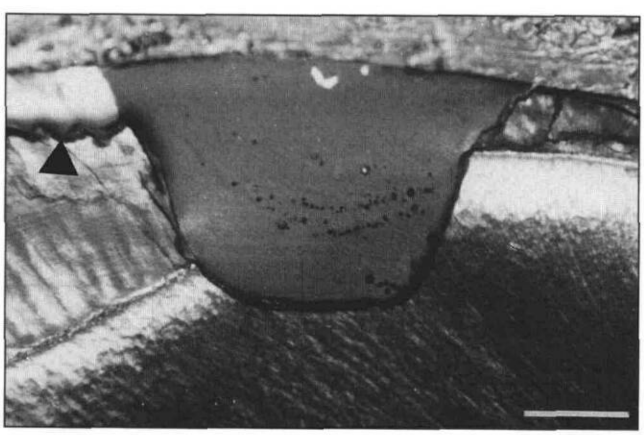

Fig 2. Ground section of a permanent tooth with a composite resin restoration seen dry in air in polarized light. An enamel lesion is seen on the incisal border of the filling (Arrow).

80–100 μm thick, was prepared from each specimen in a Leitz low-speed saw microtome® (Wetzlar, Germany) The specimens were analyzed dry in air and after water imbibition by the two authors independently under a polarized light microscope (Olympus BH with strain-free objectives—Tokyo, Japan). A lesion in the enamel was defined as a change in the pore volume distribution seen as a change in the birefringence of the enamel. The registration of a lesion was performed with coded specimens as a qualitative test where the presence or absence of artificial caries lesions on the cavity walls was recorded. To test for statistical significance of differences between the observations, Fisher's Exact Test was applied.

Results

The number of primary and permanent teeth with cavity wall lesions adjacent to composite resin and GPA restorations is presented in the Table. Significantly more lesions occurred ($P < 0.05$) in primary versus permanent enamel surrounding composite resin restorations (Figs 1, 2), whereas no significant difference between permanent and primary enamel surrounding GPA fillings was observed. No cavity wall lesions were seen in specimens kept in water.

Demineralization in the enamel peripheral to the restoration was observed in all specimens stored in the acidified solution and in one specimen of primary teeth stored in water.

Discussion

This experiment was designed to test the materials' behavior in primary and permanent enamel in an acid environment and not to reflect the oral situation with thermal and mechanical cycling.

Acetic acid was chosen for this investigation because it produces artificial caries lesions faster than lactic acid at low pH (4.5) as measured up to 30 days.[6] The test period in this study, 14 days, was chosen according to observations by Theuns, et al.,[7] who found greater mineral loss in a shorter time period, 4 to 16 days, at a lower pH (4.0–4.5) than at a higher pH (5.0, 6.0) tested for 8 to 32 days, when the saturation of hydroxyapatite and the concentration of undissociated acid were kept constant. The concentration of undissociated acid in this test was not controlled, but it has been shown that this factor has little effect at low pH.[8]

It was expected that the test solution would contain fluorides, primarily leaking from the GPA fillings,[9] and also trace amounts of analytical chemicals,[8] but their quantity was not measured. No effort was made to test the composite and GPA restorations in separate solutions since fluorides would be present in the oral environment in vivo.

The effect of fluoride in demineralizing solution has been tested on bovine enamel, which has a very low F content. Lesions were subsurface but their depth was hardly influenced by 0.12 ppm F in the solution.[10] Since experiments have shown that artificial caries varies greatly—from invisible to heavy lesions, even when kept in the same demineralizing solution[11]—the enamel of all specimens in this study was studied carefully with respect to the presence of demineralization. Artificial caries lesions peripheral to the restorations were seen in all specimens kept in the test solution and in one deciduous tooth kept in water. Since the primary teeth available for the study were not caries free, the lesion seen in the control specimen may have been caused in vivo before the tooth was extracted.

Lesions on cavity walls surrounding composite resin were seen more frequently in primary than in permanent enamel. Both cervical and incisal walls of the cavity were altered equally in this test.

Demineralization of the cavity walls implies leakage between the restoration and the cavity. Comparison of the two restorative materials has shown that curing contraction was of the same magnitude in both composite resin and GPA, the shrinkage of GPA developing slower than that of composite resin.[12] Another factor preventing demineralization in an acid environment is the content of fluorides in the restorative material as tested in GPA-lined composite resin restorations in artificial caries systems.[13] Finally, fluorides have been taken up by dental tissues surrounding GPA fillings,[14] thus decreasing the enamel solubility. In the clinical situation, the ability of GPA cements to inhibit the growth of *Streptococcus mutans* would have a favorable effect in reducing the production of acids.[15]

This study suggests that there is a difference in the performance of permanent and primary enamel surrounding composite resin. Factors explaining this difference may be found in the histological features of primary enamel. A comparison of permanent and primary enamel has shown about the same prism orientation on occlusal surfaces, but in the crystal orientation a higher angle was seen between the permanent enamel surface as compared with the primary enamel.[16] Kodaka, et al.[17] also reported a great variation in the enamel of primary incisors—from distinct prisms bending at the subsurface to prismless enamel without prism boundaries. These histologic differences and their effect on the etching of deciduous enamel in order to obtain prismatic tag pattern have been studied by several investigators.[18] Grinding the deciduous enamel surface, which has been advocated in order to obtain a prismatic pattern, seems, in fact, to facilitate the production of prism tags irrespective of etching time.[18] However, etching the deciduous enamel before applying composite resin—re-etching the enamel with subsequent sealing of the cavity margin with unfilled resin—does not seem to produce a tight seal to the restoration.

It can be concluded that the occurrence of cavity wall lesions adjacent to GPA restorations subjected to an acid environment was low, while more cavity lesions were found in primary than in permanent teeth adjacent to composite restorations.

This study was supported by a grant from Göteborgs Tändlakare-Sällskap, Göteborg, Sweden.

Dr. Varpio is assistant chief dental officer at the pedodontic clinic of the Public Dental Service of the City of Göteborg, and Dr. Noren is associate professor and chairman of the department of pedodontics, faculty of odontology, University of Göteborg, Sweden.

1. Fuks AB, Chosack A, Eidelman E: Assessment of marginal leakage around Class II composite restorations in retrieved primary molars. Pediatr Dent 12:24–27, 1990.
2. Varpio M, Warfuinge J, Norén JG: Proximo-occlusal composite restorations in primary molars: marginal adaption, bacterial penetration, and pulpal reactions. Acta Odontol Scand 48:161–67, 1990.
3. Donly KJ, Wild TW, Jensen ME: Posterior composite Class II restorations: in vitro comparison of preparation designs and restoration techniques. Dent Mater 6:88–93, 1990.
4. Hattab FN, Mok NYC, Agnew EC: Artificially formed caries-like lesions around restorative materials. J Am Dent Assoc 118:193–97, 1989.
5. Theuns HM, van Dijk JWE, Driessens FCM, et al.: Effect of time and degree of saturation of buffer solutions on artificial carious lesion formation in human tooth enamel. Caries Res 17:503–12, 1983.
6. Featherstone JDB, Rodgers BE: Effect of acetic, lactic and other organic acids on the formation of artificial carious lesions. Caries Res 15:377–85, 1981.
7. Theuns HM, van Dijk JWE, Driessens FCM, Groeneveld A: The effect of undissociated acetic-acid concentration of buffer solutions on artificial caries-like lesion formation in human tooth enamel. Arch Oral Biol 29:759–63, 1984.
8. Theuns HM, van Dijk JWE, Driessens FCM, Groeneveld A: Effect of the pH of buffer solutions on artificial carious lesion formation in human tooth enamel. Caries Res 18:7–11, 1984.
9. Forsten L: Fluoride release and uptake by glass ionomers. Scand J Dent Res 99:241–45, 1991.
10. Borsboom PCF, vd Mei HC, Arends J: Enamel lesion formation with and without 0.12 ppm F in solution. Caries Res 19:396–402, 1985.
11. de Groot JF, Borggreven JMPM, Driessens FCM: Some aspects of artificial caries lesion formation of human dental enamel in vitro. J Biol Buccale 14:125–31, 1986.
12. Feilzer AJ, De Gee AJ, Davidson CL: Curing contraction of composites and glass-ionomer cements. J Prosthet Dent 59:297–300, 1988.
13. Griffin F, Donly KJ, Erickson R: Caries inhibition by fluoride-releasing liners. Am J Dent 5:293–95, 1992.
14. Scoville RK, Foreman F, Burgess JO: In vitro fluoride uptake by enamel adjacent to a glass ionomer luting cement. ASDC J Dent Child 57:352–55, 1990.
15. Svanberg M, Mjör IA, Orstavik D: Mutans streptococci in plaque from margins of amalgam, composite, and glass ionomer restorations. J Dent Res 69:861–64, 1990.
16. Hørsted M, Fejerskov O, Larsen MJ, Thylstrup A: The structure of surface enamel with special reference to occlusal surfaces of primary and permanent teeth. Caries Res 10:287–96, 1976.
17. Kodaka T, Nakajima F, Higashi S: Structure of the so-called 'prismless' enamel in human deciduous teeth. Caries Res 23:290–96, 1989.
18. Garcia-Godoy F, Gwinnett AJ: Effect of etching times and mechanical pretreatment on the enamel of primary teeth: an SEM study. Am J Dent 4:115–19, 1991.