Fluoride exchange from glass ionomer preventive resin restorations

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Abstract

The purposes of this in vivo study were to determine if placing a sealant over a glass ionomer restoration modifies its fluoride release, and to examine the effect on glass ionomer of a 4-min application of topical fluoride. Fluoride release from glass ionomer preventive resin restorations placed in 21 bovine teeth was measured before and after removing their sealants. Fuji II, Ketac Silver, and Fuji LC were evaluated, representing the three generations of glass ionomers. Fluoride was extracted from the restorations by incubating the specimens in 5 ml deionized water and was measured by specific ion electrodes at 1 and 2 days, then once weekly for 7 weeks. The results indicated that fluoride release was not significantly different in pattern or quantity in the three types of ionomer ($P > 0.05$). A significant reduction in fluoride release occurred when the restorations were covered with a sealant when compared with control restorations of the same materials ($P < 0.001$). After removing the sealant from the glass ionomer preventive resin restorations, a significant release of fluoride occurred when compared with sealed restorations ($P < 0.001$). After 63 days in water, the unsealed restorations were subjected to a 4-min topical APF treatment and reimmersed in water for an additional 27 days to examine the ability of the various materials to absorb fluoride. The fluoride-depleted restorations treated with fluoride released significantly more fluoride than fresh, untreated ionomer restorations ($P < 0.001$) or amalgam restorations. As a result of fluoride release, the glass ionomer preventive resin restoration may afford chemical protection to the tooth if sealant loss occurs. (Pediatr Dent 16:340–45, 1994)

Introduction

Various techniques emphasizing the preservation of healthy tooth structure have been proposed to treat small occlusal carious lesions. Investigation of the preventive resin restoration or composite/sealant technique using composite as the restorative material and fissure sealant to protect sound fissures has yielded excellent results.[1–4] A preventive glass ionomer restoration also has been described in which glass ionomer substitutes for composite.[5] Improved glass ionomers called silver cermets, in which silver particles bond to the glass particles by high temperature sintering, have been advocated for the primary dentition.[6]

A third generation of glass ionomers, cured by exposure to a visible light-curing source, is used in pediatric dentistry. These ionomers contain a resin that allows immediate curing, although they also undergo a typical glass ionomer reaction consuming polyacrylic acid to attain their ultimate physical properties. The physical properties of these light-cured ionomers are better than the self-cured glass ionomers and surpass those of the cermets.[7]

Release of fluoride from glass ionomer materials is thought to protect the tooth against dental caries.[8–10] The benefit of fluoride release and subsequent adsorption is found not only in enamel immediately adjacent to glass ionomer restorations, but also in areas up to 3 mm away from the restoration margins, and may even protect the entire tooth.[11, 12] However, research is lacking concerning fluoride release from the visible light-cured glass ionomers and from glass ionomer restorations following sealant placement. The purposes of this in vitro study were: 1) to determine if sealant placement over glass ionomer restorations modifies its fluoride release, and 2) to examine the effect of a 4-min clinical application of topical APF on glass ionomer.

Methods and materials

Twenty-five extracted bovine incisors were selected for this in vitro study. The root portion of each tooth was cut off and the pulp tissue from the coronal portion removed. The teeth were debrided of soft tissue remnants and cleaned with fluoride-free pumice and water and a soft bristle brush. The prepared teeth were stored in 50-ml capped plastic vials containing 40 ml of sterile deionized water.

Twenty-one teeth were hemisectioned buccolingually in order to create a control half and an experimental half. Uniform Class V preparations were made in the labial middle third in both the experimental and the control halves using a barrel-shaped bur in a high-speed handpiece under water spray. The surface area of the preparation was 4.3 mm in diameter and 2.2 mm deep, approximating the size of the bur. The tooth halves were coated with an acid-resistant varnish except for a 1-mm rim of sound enamel surrounding the cavities. The preparations were rinsed thoroughly with an air/water spray.

Fluoride release from sealed and unsealed restorations

The 21 pairs of prepared tooth halves were divided randomly into three groups. Each group of seven specimens was restored with a different type of glass ionomer. Fuji II™ (GC Dental Industrial Corporation, Tokyo, Japan), Ketac Silver™ (ESPE, Seefeld/Oberbay, Germany), and Fuji II LC™ were prepared according to the manufacturers' instructions.

For the 21 experimental tooth halves, the preventive glass ionomer restoration was placed according to the following procedure. The cavity was conditioned with a 25% polyacrylic acid solution for 10 sec, rinsed, and dried. The surrounding enamel then was etched with 37% phosphoric acid for 20 sec, rinsed, and dried. Next, the restorative material was placed carefully into the cavity, avoiding air bubbles or voids. With a ball burnisher or plastic instrument the material was condensed and any excess material was removed, avoiding overfilling. The light-cured glass ionomer then was cured for 40 sec.

For the three experimental groups of seven specimens each, a white-tinted, light-cured sealant (Visio-Seal™, ESPE, Seefeld/Oberbay, Germany) was applied to the entire tooth surface, covering the cavity and then cured with visible light according to the manufacturer's instructions. After the sealant was set, an attempt to pry it off with a dental explorer was made; no sealants were dislodged.

For the 21 control tooth halves, divided into three groups of seven specimens each, conventional restorations of Fuji II, Ketac-Silver, or Fuji II LC were placed. All the conventional restorations were overfilled to allow for the removal of the incompletely cured surface layer. The self-curing materials were allowed to set for 5 min, and the light-cured material in the third group was cured for 40 sec. All excess material was removed with diamond finishing burs.

All specimens were stored at 37°C in individually capped, 15-ml polystyrene tubes containing 5 ml deionized water. To determine the amount of fluoride released from the specimens, fluoride ion measurements were made with a fluoride ion sensitive electrode (Fluoride electrode with BNC connector, Orion Research Inc, Boston, MA) after 1 and 2 days for the first week and then once weekly for 7 weeks. Each tooth specimen was removed from the test tube and transferred to a test tube containing 5 ml of fresh deionized water. The samples were stored frozen until their analysis.

Fluoride ion concentrations were measured with a fluoride ion sensitive electrode, calibrated with a standard sodium fluoride solution (100 ppm). An experimental curve of relative millivolts versus fluoride concentration was constructed using various buffered dilutions of the standard solution (Sodium Fluoride Standard [100 ppm], Orion Research Inc, Boston, MA). The total amount of fluoride released into the storage medium in a specific time period was calculated from the calibration curve, then 250 µl of each sample was mixed with 250 µl of total ionic strength adjustment buffer (TISAB with CDTA, Orion Research Inc, Boston, MA), and these fluoride concentrations then were measured.

Fluoride release after loss of sealant

After 4 weeks, the sealants of the 21 experimental halves were removed to simulate sealant loss from a tooth restored with a preventive resin restoration. The sealant was removed with a high-speed diamond flat disc, removing as little as possible of the glass ionomer cement underlying material. All samples then were handled and analyzed for fluoride release as they were during the first 4 weeks.

Fluoride release after topical charging

After 9 weeks, 36 of the 42 fluoride-depleted tooth halves were subjected to a 4-min application of 1.2% APF topical gel and washed for 15 sec with deionized water (Fluorocare™ — Time Saver, 1.2% APF topical gel, pH 3.0–4.0 Gel-Cam, Colgate-Palmolive Co, Dallas, TX). One specimen from each group (N = 6) remained untreated with fluoride. As an additional control, amalgam restorations were placed in four virgin teeth. Varnish was applied to the tooth surrounding the restoration and the specimens then were subjected to a 4-min application of 1.2% APF topical gel.

All teeth were stored at 37°C in individually capped, 15-ml polystyrene tubes containing 5 ml deionized water. To determine the amount of fluoride released from the specimens, fluoride ion measurements were made after 2 and 4 days for the first week and then once weekly for 3 more weeks.

Data were analyzed using an unpaired Student's *t*-test and for multiple comparisons, one-way repeated and nonrepeated measures analysis of variance (ANOVA) tests. When the overall ANOVA was signifi-

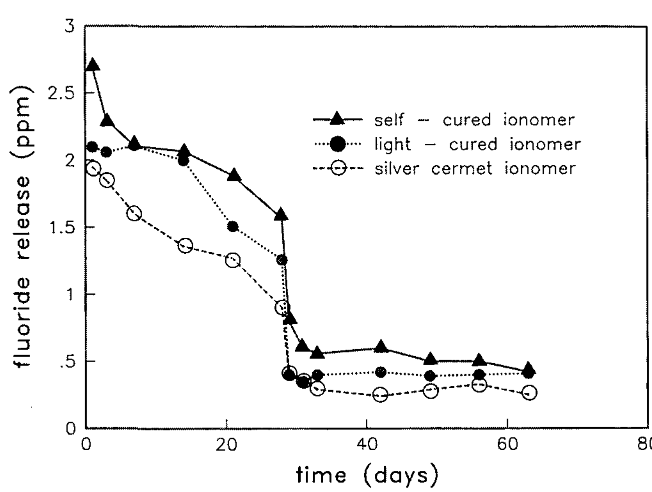

Fig 1. Comparison of fluoride release from various types of glass ionomer conventional restorations.

Table 1. Fluoride release (mean ppm ± SD) from different restorative materials used as preventive or conventional restorations

	Self-Cured Glass Ionomer		*Light-Cured Glass Ionomer*		*Silver Cermet*	
Time (Days)	*Preventive Restoration*	*Conventional Restoration*	*Preventive Restoration*	*Conventional Restoration*	*Preventive Restoration*	*Conventional Restoration*
1	0.36 ± 0.23	2.71 ± 0.29	0.34 ± 0.15	2.10 ± 0.06	0.19 ± 0.11	1.96 ± 0.15
3	0.21 0.28	2.26 0.34	0.12 0.07	2.06 0.11	0.06 0.04	1.86 0.51
7	0.22 0.17	2.11 0.07	0.16 0.15	2.11 0.24	0.16 0.20	1.60 0.67
14	0.21 0.06	2.07 0.05	0.22 0.11	2.00 0.19	0.24 0.30	1.36 0.80
21	0.08 0.04	1.89 0.19	0.18 0.13	1.51 0.39	0.11 0.13	1.27 0.74
28*	**0.11 0.01**	**1.57 0.43**	**0.36 0.39**	**1.26 0.57**	**0.12 0.12**	**0.94 0.59**
29	2.01 0.04	0.84 0.50	1.71 0.39	0.40 0.13	1.66 0.24	0.43 0.24
31	1.20 0.38	0.64 0.40	0.74 0.22	0.36 0.12	1.26 0.24	0.37 0.44
33	0.90 0.38	0.57 0.30	0.61 0.27	0.40 0.07	0.76 0.21	0.29 0.13
42	0.91 0.29	0.60 0.13	0.63 0.18	0.43 0.13	0.90 0.41	0.25 0.08
49	0.35 0.20	0.51 0.19	0.46 0.26	0.39 0.11	0.82 0.47	0.29 0.10
56	0.26 0.19	0.51 0.19	0.25 0.13	0.40 0.12	0.37 0.19	0.33 0.20
63	0.29 ± 0.19	0.43 ± 0.26	0.30 ± 0.12	0.41 ± 0.15	0.39 ± 0.17	0.25 ± 0.11

(N = 7) for each group. Figures report amount released since previous measurement.

*Sealants were removed from preventive restorations after the 28-day reading.

cant, a Tukey's pair-wise multiple comparison test was used to determine which pairs of groups were statistically different. When the various parts of the experiment were compared, the nonparametric Kruskal-Wallis ANOVA was employed due to the lack of homogeneity of the standard deviation.

Results

Fig 1 and Table 1 demonstrate that all materials, when used as conventional restorations, release some fluoride with a similar pattern of release ($P > 0.05$, F = 2.05). The greatest amount of fluoride was released during the first day, gradually decreasing until the 28th day, when a precipitous decrease in the amount released was followed by a rather constant rate of decrease through the end of the experiment.

Fig 2 and Table 1 illustrate the fluoride release from various types of glass ionomer materials when used as preventive restorations and covered by a sealant material. As long as the sealant was present, there was almost no fluoride release, which is substantially different from the fluoride released from these materials without sealant ($P < 0.001$; t = 28.72, 24.5, 17.02, for light-, silver-, and self-polymerized materials). When the sealants were removed at day 28, a significant burst of fluoride occurred ($P < 0.001$; t = 8.31, 9.58, 6.15, for light-, silver-, and self-polymerized materials), which lasted for a few days and was similar in degree to all

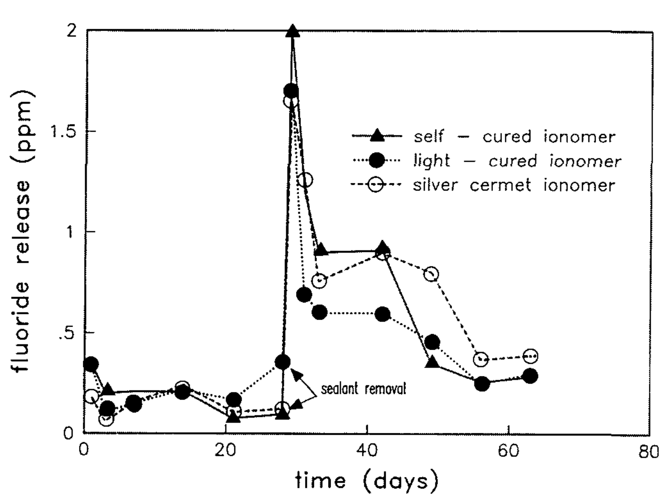

Fig 2. Comparison of fluoride release from various types of glass ionomer preventive resin restorations in which a sealant had been placed and then removed after 25 days.

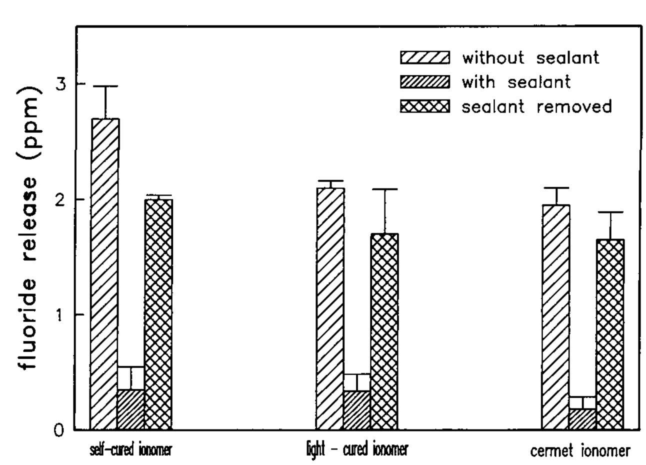

Fig 3. Comparison of fluoride release from various types of glass ionomer materials on the first day following placement, and following removal of the sealant.

Table 2. Fluoride release (mean ppm ± SD) following fluoride treatment after 64 days

Time (Days)	Self-Cured Glass Ionomer Treated (N = 12)	Self-Cured Glass Ionomer Nontreated Control (N = 2)	Light-Cured Glass Ionomer Treated (N = 12)	Light-Cured Glass Ionomer Nontreated Control (N = 2)	Silver Cermet Treated (N = 12)	Silver Cermet Nontreated Control (N = 2)	Amalgam Treated (N = 4)
65	6.33 ± 2.61	0.15 ± 0.04	10.18 ± 3.49	0.25 ± 0.04	12.9 ± 5.22	0.22 ± 0.14	0.27 ± 0.05
69	0.94 0.59	0.15 0.04	2.54 1.83	0.19 0.01	1.88 0.58	0.19 0.07	0.05 0.01
76	0.93 0.59	0.15 0.04	1.04 0.43	0.15 0.03	0.93 0.30	0.25 0.13	0.04 0.01
83	0.71 0.42	0.15 0.04	0.87 0.45	0.13 0.01	0.97 0.38	0.16 0.03	0.03 0.01
90	0.54 ± 0.34	0.14 ± 0.06	0.63 ± 0.36	0.09 ± 0.01	0.43 ± 0.27	0.13 ± 0.06	0.02 ± 0.01

Figures report amount released since previous measurement.

three types of ionomer materials. This release was similar to — although somewhat lower than — the amounts of fluoride released from conventional materials during the first weeks after placement. The fluoride release decreased gradually, yet remained higher than the controls, until the 49th day, when the control and experimental groups had no significant differences.

For comparison, Fig 3 illustrates the amount of fluoride released by all three glass ionomer materials with and without sealant the first day after placing and the first day after removing the sealants. Fig 3 shows the great difference in fluoride release when the sealant is present.

Fig 4 and Table 2 illustrate the fluoride release immediately following topical fluoride application. The six nontreated, restored control halves and the four teeth with amalgam restorations that had received a topical fluoride treatment showed no increase in fluoride release. However, the fluoride-depleted glass ionomer restorations showed a dramatic increase in fluoride release following topical fluoride treatment. The amount of fluoride released following fluoride treatment was significantly higher than the initial release for all materials ($P < 0.001$; $t = 7.84, 7.24$, and 4.76 for the light-, silver-, and self-polymerized materials). This high fluoride release dropped quickly after 4 days, and then leveled off to a constant, relatively high daily release for the duration of the experiment. Although the fluoride release pattern was similar for all materials, the initial fluoride release was significantly higher in the cermet group than the self-cured glass ionomers.

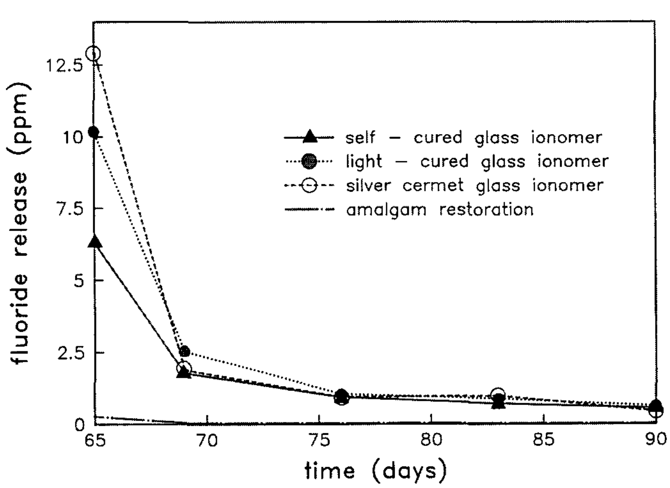

Fig 4. Comparison of fluoride release following topical fluoride treatment of various types of fluoride – depleted glass ionomer restorations.

Discussion

When glass ionomer materials were introduced, practitioners suggested that they might have a cariostatic effect due to fluoride release after placing the material. This study has demonstrated that when glass ionomer materials are used as preventive restorations and are covered with sealant, fluoride is not released as quickly as when no sealant is present. This study also suggests that fluoride remains readily available from within the ionomer material and is released if and when the sealant is lost. This would provide a distinct advantage of glass ionomers compared with composite materials for the preventive resin restoration.

In this study, the fluoride released after removing the sealant from the preventive restorations was not as great as the initial amount of fluoride released with a conventional restoration without a sealant. This difference may have been due to tags of sealant that remained embedded within the surface of the ionomer material, even though the sealant was removed carefully and none appeared to have remained. If remnants of the sealant did surround the glass particles — forming a barrier — it would have prevented the full release of fluoride. In clinical practice, sealants are often partially rather than completely lost. When used with a glass ionomer preventive restoration, the sealant would act to maintain the reservoir of fluoride, which would be released only as parts of the sealant were lost. The results of this study, showing a slightly higher amount of fluoride release from self-cured Fuji II compared with silver cermet, agree with other studies.[13–17] However, no studies have been published regarding fluoride release from light-cured Fuji II. It is likely that there would be no clinically meaningful difference in fluoride release among all three materials.

Fluoride release consists of three different components: release into the underlying tooth structure adjacent to the restoration (cavity walls and floor), release into the fissure system of the restored tooth, and release into the saliva affecting other teeth in the oral cavity. The fluoride analyzed in this in vitro study may be compared with the component of in vivo fluoride released into the oral cavity. However, many differences exist between the in vitro and clinical situations, and this study may not represent what actually takes place within the oral environment.

In the second part of this study, the ability to recharge a fluoride-depleted restoration was examined. In contrast with previous studies[18-20] demonstrating that composite resins do not absorb significant amounts of fluoride, this study showed that glass ionomer materials are capable of absorbing and releasing significant amounts of fluoride. This provides a significant clinical advantage for these materials as their fluoride reservoirs can be refilled, potentially increasing the caries-protective effect.

The composite/sealant-type restoration is recommended for posterior teeth in which caries has been confined to a limited part of the occlusal surface, particularly with the first permanent molar. If a fluoride-releasing material such as a glass ionomer was used, caries recurrence might be expected to be very low and there would be no need to replace the conservative restoration with a larger one. The rationale behind a glass ionomer preventive resin restoration is sealing in the fluoride, thus ensuring long-term fluoride release. Fluoride would be released only when it is needed (after sealant loss has occurred). Secondary caries is reported to be the reason for more than 50% of the amalgam filling replacements.[21, 22] In contrast, secondary caries is seldom found adjacent to glass ionomer restorations, probably due to the material's high fluoride content.[19, 23]

The ability of a tooth to absorb fluoride depends on the baseline level of fluoride — the lower the baseline, the higher the uptake.[11, 24] This means that the teeth that need fluoride most will benefit the most from glass ionomers.[25] Glass ionomers release fluoride at a constant, low level. However, it is unclear when this effect dissipates completely. The potential to recharge glass ionomer supports investigation into the long-term effects of fluoride release from this material.[26] In the case of the glass ionomer-preventive resin restoration, the benefits of long-term fluoride release may be sealed in until the sealant is lost.

Conclusions

1. Glass ionomer materials release significantly more fluoride when placed as conventional restorations with no sealant covering.
2. After sealant removal, glass ionomer preventive resin restorations provide a significant increase in fluoride release.
3. All three glass ionomer materials tested released comparable amounts of fluoride over similar periods of time.
4. All three glass ionomers, when given 4-min topical fluoride APF treatment, released higher levels of fluoride compared with controls.

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1. Simonsen RJ, Stallard RE: Sealant restorations utilizing a diluted filled resin: one year results. Quint Int 8:77–84, 1977.
2. Simonsen RJ: Preventive resin restorations: three year results. J Am Dent Assoc 100:535–39, 1980.
3. Houpt M, Fuks A, Eidelman E, Shey A: Composite/sealant restoration: 6-1/2 year results. Pediatr Dent 10:304–6, 1988.
4. Ripa LW, Wolff MS: Preventive resin restorations: indications, technique, and success. Quint Int 23:307–15, 1992.
5. Garcia-Godoy F: The preventive glass ionomer restoration. Quint Int 17:617–19, 1986.
6. Croll TP, Phillips RW: Six years' experience with glass ionomer-silver cermet cement. Quint Int 22:783–93, 1991.
7. Croll TP, Killian CM: Visible light-hardened glass-ionomer-resin cement restorations for primary teeth: new developments. Quint Int 23:679–82, 1992.
8. Rezk-Lega F, Ogaard B, Arends J: An in-vitro study on the merits of two glass ionomers for the cementation of orthodontic bands. Am J Orthod Dentofacial Orthop 99:162–67, 1991.
9. Svanberg M: Class II amalgam restorations, glass ionomer tunnel restorations, and caries development on adjacent tooth surface: a 3-year clinical study. Caries Res 26:315–18, 1992.
10. Tyas MJ: Cariostatic effect of glass ionomer cement: A five year clinical study. Austr Dent J 36:236–39, 1991.
11. 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.
12. Retief DH, Bradley EL, Denton JC, Switzer P: Enamel and cementum fluoride uptake from a glass ionomer cement. Caries Res 18:250–57, 1984.
13. Horsted-Bindslev P, Larsen MJ: Release of fluoride from conventional and metal-reinforced glass ionomer cements. Scand J Dent Res 98:451–55, 1990.
14. Forsten L: Short- and long-term fluoride release from glass ionomers and other fluoride containing filling materials in vitro. Scand J Dent Res 98:179–85, 1990.
15. DeSchepper EJ, Berr EA, Cailleteau JG, Tate WH: A comparative study of fluoride release from glass ionomer cements. Quint Int 22:215–19, 1991.
16. Swartz ML, Phillips RW, Clark HE: Long-term fluoride release from glass ionomer cements. J Dent Res 63:158–60, 1984.
17. El-Mallakh B, Sarkar NK: Fluoride ion release from glass ionomer cement in deionized water and artificial saliva. J Dent Res 67:197, 1988.
18. Swift EJ: In vitro caries inhibitory properties of a silver cermet. J Dent Res 68:58–65, 1989.
19. Hicks MJ, Flaitz CM, Silverstone LM: Secondary caries formation *in vitro* around glass ionomer restorations. Quint Int 17:527–32, 1986.

20. Serra MC, Cury JA: The in vitro effect of glass ionomer cement restoration on enamel subjected to a demineralization and remineralization model. Quint Int 223:143–47, 1992.
21. Mjor IA: Placement and replacement of restorations. Oper Dent 6:49–54, 1981.
22. Dahl JE, Eriksen HM: Reasons for replacements of amalgam dental restorations. Scand J Dent Res 86:404–7, 1978.
23. McLean JW, Wilson AD: Fissure sealing and filling with an adhesive glass ionomer cement. Br Dent J 136:269–76, 1974.
24. Skartveit L, Tveit AB, Totdal B, Overbo R, Raadal M: In vivo fluoride uptake in enamel and dentin from fluoride-containing materials. ASDC J Dent Child 57:97–100, 1990.
25. 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.
26. Berg JH, Farrell JE, Brown LR: Class II glass ionomer/silver cermet restorations and their effect on interproximal growth of mutans streptococci. Pediatr Dent 12:20–23, 1990.

New CPR Technique shows promise in the field

Active compression-decompression CPR improves short-term survival

The most promising new development in cardio-pulmonary resuscitation (CPR) in more than 30 years may result from a serendipitous encounter with a plunger. Active compression-decompression (ACD) CPR appears to be more effective than standard CPR for some patients, according to an article in a recent *Journal of the American Medical Association.*

ACD CPR was developed by physicians who received a patient with a history of heart trouble who collapsed in front of his family. The patient was unrousable, but his son, poorly trained in traditional CPR, took a plunger and plunged his father's chest for 10 minutes until paramedics arrived. In a letter to *JAMA* (10/3/90, Lurie et al, p. 1661), the physicians described the event and speculated that "the suction between the chest wall and the plunger generated significant negative pressure and served to ventilate the patient as well."

Subsequent research indicated that "a handheld suction device applied to the chest during CPR indicated that ACD CPR, when compared with standard CPR, improves multiple hemodynamic and respiratory parameters during ventricular fibrillation, asystole, and electromechanical dissociation," writes Keith G. Lurie, MD, from the Department of Medicine, University of Minnesota School of Medicine, Minneapolis, with colleagues.

The authors conducted a 10-month (July 18, 1992, to May 14, 1993), prospective, randomized parallel-group trial in St. Paul, Minn., to assess the potential benefits of the technique. Patients were included if they were older than 8 years, suffered a nontraumatic out-of-hospital cardiac arrest, and had normal temperature.

The ACD device has a silicone rubber suction cup, a circular plastic handle containing a force gauge, and a connection stem. It was applied to the midsternum at the level of the nipples; compression was performed in accordance with American Heart Association guidelines, with decompression (actively lifting up on the handle) interposed between compression strokes.

There were 130 out-of-hospital arrests during the study period; 77 patients received standard CPR and 53 received ACD CPR. The treatment groups were similar in mean age, sex, mean weight, mean height and known history of heart disease.

"Return of spontaneous circulation, ICU admission, and neurological recovery in both CPR groups were highly correlated with downtime (time from collapse to emergency medical system personnel arrival to the scene in witnessed arrests)," they write.

"In patients with less than 10 minutes between collapse and arrival of the first response team to the scene, there was a significant increase in the ICU admission rates with ACD CPR (59%) compared with standard CPR (33%). Improvement in short-term survival in victims of out-of-hospital cardiac arrest of this magnitude has not been reported since the first description of manual CPR more than three decades ago."

When all patients were considered, "a higher percentage of ACD CPR patients had a return of spontaneous circulation and were admitted to the ICU vs. standard CPR (45% vs. 31%, and 40% vs. 26%, respectively), but these trends were not statistically significant."

They write: "This study demonstrates that ACD CPR appears to be more effective than standard CPR in a well-defined subset of victims of out-of-hospital cardiac arrest during the early phases of resuscitation. Based on this study, a larger study should be performed to evaluate the potential long-term benefits of ACD CPR."