

## Microleakage of three luting agents used with stainless steel crowns

Joel H. Berg, DDS, MS David E. Pettey, DDS  
Max O. Hutchins, PhD

### Abstract

*The microleakage through margins of stainless steel crowns cemented with polycarboxylate, zinc phosphate, or glass ionomer cement was evaluated by measuring the amount of <sup>45</sup>Ca leakage through the crown margins through 56 days after cementation in an in vitro environment. There was no cement-specific difference in marginal leakage as measured by this technique. The amount of leakage for each cement stabilized three days after crown placement and remained constant throughout the experimental period. The data suggest that the newer glass ionomer cement provides comparable protection to that of the other two traditional cements used with stainless steel crowns.*

Glass ionomer cement is the newest introduction to cements used for placing stainless steel crowns.

The adaptation of glass ionomer material to tooth structure has been shown to be better than the adaptation of other restorative materials (Chan et al. 1985; McLean et al. 1985; Norris et al. 1986; Hicks et al. 1986). The close adaptation of glass ionomer to dentin and enamel has precipitated the development of formulations of glass ionomer for cementing extracoronary restorations.

Yet, it is quality of the tooth preparation for the stainless steel crown in conjunction with the cement (Rector et al. 1985; Savide et al. 1979; Noffsinger et al. 1983) which retain the cemented crown onto primary teeth. Therefore, the most important properties of using a luting agent in the placement of stainless steel crowns onto primary teeth are those relating to resistance to local environmental factors.

The amount of microleakage through the stainless steel crown margin is of particular concern (Andrews et al. 1976; Grieve et al. 1981). Many studies have examined various cements in terms of microleakage by using dye penetration and radiopermeability techniques (Mondelli and Galan 1987; Myers et al. 1983; Gordon et

al. 1985; Shen and Herrin 1986). Dye penetration studies examine the permeability of the margin to a dye, after which an assessment of the linear amount of penetration is made (Crim and Shay 1987; Kanca 1987; Gordon et al. 1986). Radiopermeability studies do not require direct identification of leakage by the investigator in terms of penetration, as the measurement is determined by the scintillation counting device. The scintillation counting device quantitatively measures the amount of radioactivity in a solution which has traversed a margin or junction (Herrin and Shen 1985). This latter technique is thus appropriate for producing a continuous variable subject to parametric statistical interpretation. Little has been done to examine the luting agent-related permeability of the cemented stainless steel crown using any technique.

The purpose of this investigation was to determine the amount of microleakage through the margins of stainless steel crowns cemented onto primary teeth with glass ionomer cement relative to the marginal microleakage of stainless steel crowns cemented with zinc phosphate and polycarboxylate cements.

### Materials and Methods

Twenty primary molars were selected from a supply of exfoliated or extracted teeth from the Department of Pathology at The University of Texas Dental Branch. Teeth were selected that had little or no decay, and sufficient intact tooth structure so that a good crown marginal seal could be obtained on the basis of a good clinical examination. Each of the 20 teeth were hand scaled and cleaned to remove debris and stored in room temperature tap water. Teeth (specimens) were mounted in a self-curing acrylic base to allow ease in handling. Each specimen was weighed and the acrylic was trimmed so that each specimen weighed 4.5 g.

The acrylic was coated with polyurethane to provide a sealed surface. Standard stainless steel crown preparations were made on all teeth. A #6 round bur-size hemispherical preparation was made at the center of the occlusal surface. A pretrimmed and precrimped stainless steel crown (Ion — 3M Dental Products Division; St Paul, MN) was custom fitted for each tooth. Each crown was crimped and contoured to allow for the best marginal fit achievable on the basis of a thorough examination with an explorer. The specimens were randomly divided into four groups. Each specimen was labeled by group; i.e., control (no cement), zinc phosphate (Fleck's Cement — Mizzy Inc, Clifton Forge, VA), polycarboxylate (Durelon — Premier Dental Products Co, Norristown, PA), or glass ionomer (Ketac-Cem — ESPE-Premier Sales Corp, Norristown, PA). The specimens were dried thoroughly and a damp cotton pellet (deionized water) was placed in the occlusal recess (Fig 1).

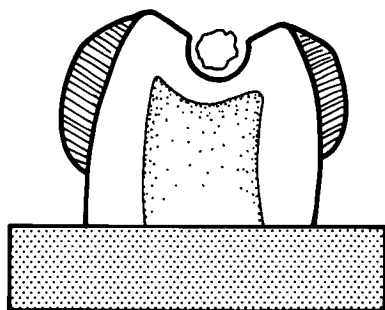


FIG 1. Pellet containing  $^{45}\text{Ca}$  placed into occlusal well.

Five microliters of a 2.0  $\mu\text{Ci}/\mu\text{l}$  solution of  $^{45}\text{Ca}$  was pipetted onto the saturated cotton pellet of each specimen. Each custom crown was cemented or placed onto its specific specimen (Fig 2). Each specimen then was positioned in its own 8-oz jar containing 70 ml of physiologic saline, and a screw-top lid was placed (Fig 3). The jars were put into a large electric water bath maintained at 37°C and then submerged about two-thirds of their height.

One day, 3 days, 7 days, and 8 weeks after placement of the crowns, two 50- $\mu\text{l}$  samples of fluid were pipetted from each specimen jar and placed into separate scintillation mini-vials. Six ml of scintillation fluid (Ready Solv™ — Beckman; Fullerton, CA) was added to each of the 40 vials. The vials were lidded, labeled, and placed in counting racks in which scintillations per minute were measured by a liquid scintillation counter (Beckman).

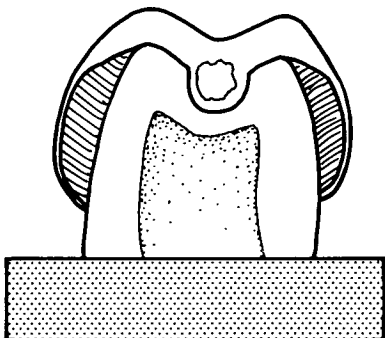


FIG 2. Crown placement.

## Results

The radioactivity in each sample was corrected for background; the counting efficiency was calculated using the external standard method and was expressed as disintegrations per minute.

Disintegrations per minute were corrected to express what would have been the original level of activity considering the 164-day half life of  $^{45}\text{Ca}$  using the equality:

$$A = A_0 e^{(-0.693t/T_{1/2})}$$

where:

A = converted activity at time of sample

$A_0$  = original activity of isotope (2.0  $\mu\text{Ci}/\mu\text{l}$ )

t = number of days after isotope production  $T_{1/2}$  = half life of  $^{45}\text{Ca}$  (164 days)

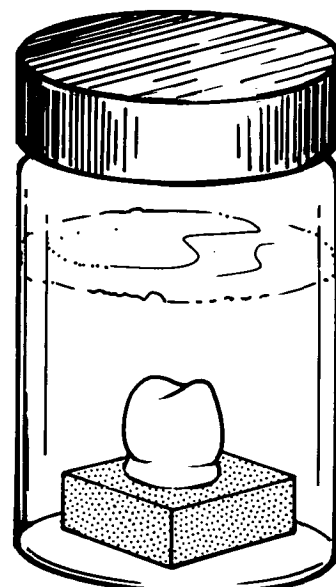


FIG 3. Specimen immersed in saline.

Analysis of variance confirmed no significant difference between the leakage of radioisotope through the margins of crowns placed without cement and those placed with any of the three cements at each of the four sampling times after crown placement (Fig 4). There was no statistical difference in the leakage of radioisotope through the margins of crowns cemented with glass ionomer cement, zinc phosphate cement, and polycarboxylate cement at any sampling time postcementation. Scintillation counts were statistically lower one day postcrown placement than at any subsequent sampling time through 56 days ( $P < .05$ ; Fig 4). Radioisotope leakage through the margins of all specimens was not detectably different at any sampling time after 1 day for any of the cements.

## Discussion

This study used the stainless steel crown placed or cemented onto a primary tooth in a model in vitro environment to examine the differential permeability of various luting agents commonly used to place stainless steel crowns in children. The results indicate that there is no differential permeability of the three luting agents to  $^{45}\text{Ca}$ . Additionally, the results show a stabilization of isotope leakage by day 3, with a maintenance of the levels of leakage though the final 8-week evaluation after the initial (1-day) sample was taken.

The results suggest that each of the three tested luting agents provide an equivalent inhibition of perfusion of isotope through the margins of the cemented

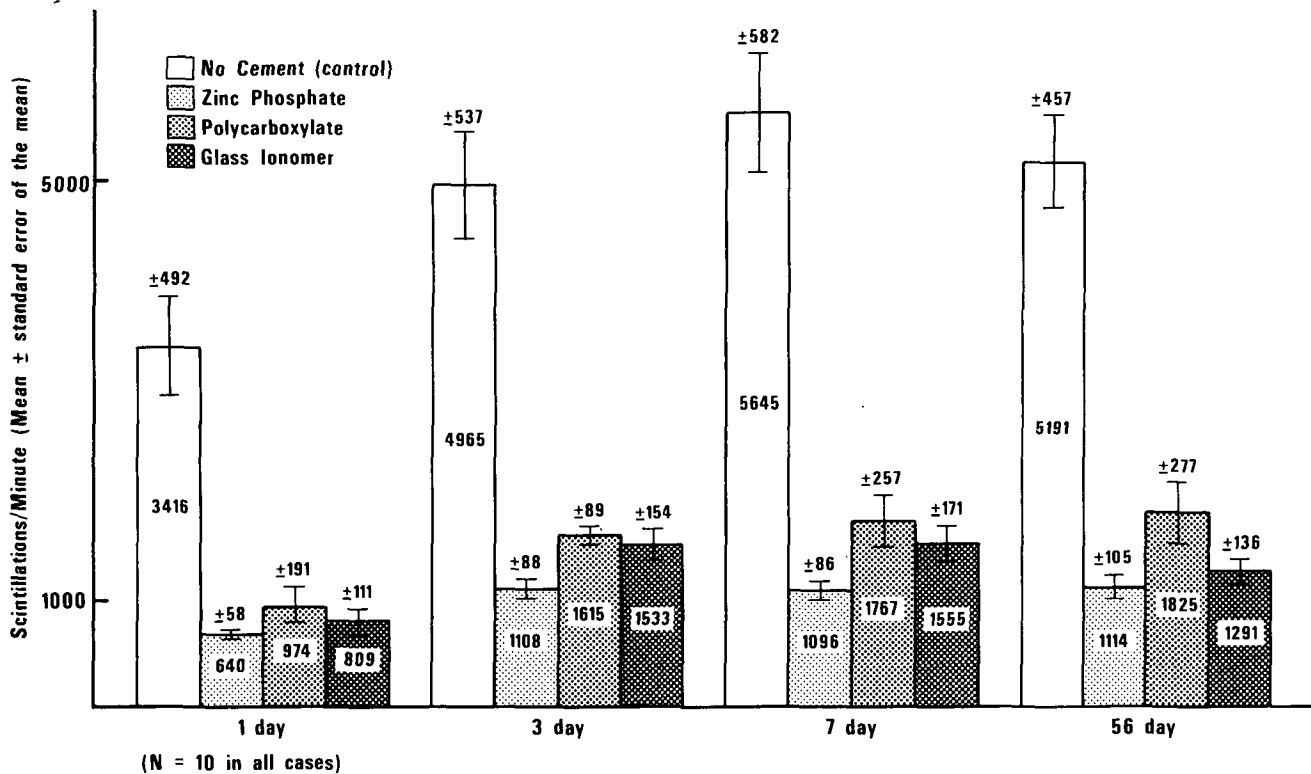


FIG 4. Scintillations/min converted to disintegrations/min (mean  $\pm$  SE of the mean) for each cement-specific group of specimens at each sampling time.

stainless steel crowns. Although the measured leakage of  $^{45}\text{Ca}$  through the cement margins does not necessarily equate with the clinical leakage of oral environment fluids, it gives a good approximation of the capability of the various luting agents to act as a permeability barrier.

Minimizing permeability to oral fluids near the margin of stainless steel crowns is important for prevention of secondary carious attack (Hicks et al. 1986). The crowns placed in this study without a luting agent exhibited about 4 times the leakage of isotope through the crown margins at each of the sampling times compared with any of the crowns placed with cements. The agent used between the internal aspect of the stainless steel crown and the tooth acts as a medium by which resistance to permeation is provided (Norris et al. 1986; Knibbs et al. 1986). When glass ionomer cement has been used to lute orthodontic bands which were subsequently subjected to tensile forces to evoke their removal, it was found that the glass ionomer remained firmly bound to the tooth structure, and the failure occurred at the glass ionomer/band interface (Norris et al. 1986). This phenomenon might result in the formation of "coping" of glass ionomer cement which could resist contact of oral substances and underlying tooth structure.

The *in vivo* disintegration of glass ionomer cement

has been shown to be less than that of polycarboxylate or zinc phosphate cements over a 12-month period (Phillips et al. 1987). The film thickness of glass ionomer cement has been demonstrated to be acceptable relative to other luting cements (Wong and Bryant 1986). These facts together with the knowledge that a bond is formed between the glass ionomer cement and tooth structure suggest that glass ionomer cement, when used as a luting agent clinically, will exhibit acceptable maintenance of favorable properties.

Several investigators have either scientifically or anecdotally provided information suggesting postcementation sensitivity using glass ionomer as a luting agent with permanent tooth crowns (Smith and Ruse 1986; American Dental Association Council on Dental Materials 1984). The present report suggests that increased permeability to oral fluids can be ruled out as a potential source of cement-specific sensitivity after cementation of stainless steel crowns placed onto primary teeth.

Fluoride release from the glass ionomer luting agent may provide beneficial characteristics not inherent to other luting agents. Other reports have shown that fluoride release from glass ionomer materials is of sufficient concentration to alter bacterial growth (Tobias et

al. 1985; Jedrychowski et al. 1983), and to avert carious attack at margins of restorations (Hicks et al. 1986). Although our data suggest that glass ionomer cement does not exhibit less leakage of isotope through the margin of stainless steel crowns than the other cements, there may be advantages to its use not inherent to these other luting materials.

## Conclusions

The findings of this study suggest that: (1) there is no apparent differential permeability of glass ionomer, zinc phosphate, and polycarboxylate cements when used as a luting agent with stainless steel crowns on primary teeth; and (2) the leakage of radioactive  $^{45}\text{Ca}$  isotope through the margin of stainless steel crowns cemented with any of the above media stabilizes by the third day after cementation, and is maintained at the same level for at least 8 weeks.

These findings show that the microleakage of glass ionomer cement is not greater than the microleakage of zinc phosphate or polycarboxylate cements when used to lute stainless steel crowns onto primary molars.

Dr. Berg is an assistant professor, pediatric dentistry, and Dr. Hutchins is a professor and chairman, physiology, The University of Texas Dental Branch; Dr. Pettey is a resident, West L.A. Veteran's Administration, Los Angeles, California. Reprint requests should be sent to Dr. Joel H. Berg, Dept. of Pediatric Dentistry, The University of Texas Dental Branch, Houston, TX 77225.

American Dental Association Council on Dental Materials. Reported sensitivity to glass ionomer luting cements. *J Am Dent Assoc* 109:476, 1984.

Andrews KS, Hembree JH: In vivo evaluation of marginal leakage of four inlay cements. *J Prosthet Dent* 35:532-7, 1976.

Chan DC, Reinhardt JW, Schuelein TM: Bond strengths of restorative materials to dentin. *Gen Dent* 33:236-8, 1985.

Crim AC, Shay JS: Microleakage pattern of a resin-veneered glass ionomer cavity liner. *J Prosthet Dent* 58:273-75, 1987.

Gordon M, Plasschaert AJM, Soelberg KB, Bogdan MS: Microleakage of four composite resins over a glass ionomer cement base in Class V restorations. *Quintessence* 12:817-20, 1985.

Gordon M, Plasschaert AJM, Stark MM: Microleakage of several tooth-colored restorative materials in cervical cavities. A comparative study in vitro. *Dent Mater* 2:228-31, 1986.

Grieve AR, Jones JC: Marginal leakage associated with four inlay cementing materials. *Br Dent J* 151:331-34, 1981.

Herrin HK, Shen C: Microleakage of root caries restorations. *Gerodontology* 1:156-59, 1985.

Hicks MJ, Flaitz CM, Silverstone LM: Secondary caries formation in vitro around glass ionomer restorations. *Quintessence* 17:527-32, 1986.

Jedrychowski JR, Caputo AA, Kerper S: Antibacterial and mechanical properties of restorative materials combined with chlorhexidines. *J Oral Rehabil* 10:373-81, 1983.

Kanca J: Posterior resins: microleakage below the cements/enamel junction. *Quintessence Int* 18:347-49, 1987.

Knibbs PJ, Plant CG, Shovelton DS: The performance of a zinc polycarboxylate luting cement and a glass-ionomer luting cement in general dental practice. *Br Dent J* 160:13-15, 1986.

McLean JW, Powis DR, Prosser HJ, Wilson AD: The use of glass ionomer cements in bonding composite resins to dentin. *Br Dent J* 158:410-14, 1985.

Mondelli J, Galan J: Marginal microleakage in cemented complete crowns. *J Prosthet Dent* 40:632-36, 1987.

Myers ML, Staffanou RS, Hembree JH, Wiseman WB: Marginal leakage of contemporary cementing agents. *J Prosthet Dent* 50:513-15, 1983.

Noffsinger DP, Jedrychowski JR, Caputo AA: Effects of polycarboxylate and glass ionomer cements on stainless steel crown retention. *Pediatr Dent* 5:68-71, 1983.

Norris DS, McInnes-Ledoux P, Schwaninger B, Weinberg R: Retention of orthodontic bands with new fluoride-releasing cements. *Am J Orthod* 89:206-11, 1986.

Phillips RW, Swartz ML, Lund MS, Moore BK, Vickery J: In vivo disintegration of luting cements. *J Am Dent Assoc* 114:489-92, 1987.

Rector JA, Mitchell RJ, Spedding RH: The influence of tooth preparation and crown manipulation on the mechanical retention of stainless steel crowns. *ASDC J Dent Child* 52:422-27, 1985.

Savide NL, Caputo AA, Luke LS: The effect of tooth preparation on the retention of stainless steel crowns. *ASDC J Dent Child* 46:25-29, 1979.

Shen C, Herrin K: Assessment of microleakage of restorative materials by a diffusion model. *J Oral Rehabil* 13:355-63, 1986.

Smith DC, Ruse ND: Acidity of glass ionomer cements during setting and its relation to pulp sensitivity. *J Am Dent Assoc* 112:654-57, 1986.

Tobias RS, Browne RM, Wilson CA: Antibacterial activity of dental restorative materials. *Int Endod J* 18:161-71, 1985.

Wong TCC, Bryant RW: Glass ionomer cements: some factors in film thickness. *Aust Dent J* 31:81-85, 1986.