The extent of slits at the interfaces between luting cements and enamel, dentin and alloy

GUDBRAND ØILO

NIOM – Scandinavian Institute of Dental Materials, Oslo, Norway and Department of Prosthetics, Dental Faculty, University of Oslo, Oslo, Norway

Øilo, G. The extent of slits at the interfaces between luting cements and enamel, dentin and alloy. *Acta Odontol. Scand.* 36, 257–261

Four different cements were used to assess the presence of slits at the cement/tooth or the cement/alloy interfaces using a tooth-crown model. The model consisted of ground sections of teeth and plane plates of silver/palladium alloy. The plates were fixed with bolts between two brass plates and with three different dimensions of the cement film between tooth and alloy, i.e. 50 μm, 100 μm and 200 μm. The tooth-alloy specimens were sectioned and the adaption of cements was studied with an indirect technique (replica) in a scanning electron microscope. The extent of slits was expressed as the length of all slits relative to the total length of the interface in each specimen.
The results showed that the zinc phosphate cement and polycarboxylate cement exhibited a slight to moderate tendency to formation of slits at the interfaces. The EBA cement had a small extent of slits adjacent to thin cement films, but more slits were observed with increasing film thickness. The composite resin cement had a marked tendency to slit formation independent of the cement film thickness.

Key-words: Dental materials; fixed partial prosthesis; adhesion

Gudbrand Øilo, Department of Prosthetics, Dental Faculty, University of Oslo, Geitmyrsvn. 69, Oslo 4

A previous study on the adaption of cements to teeth and the fitting surfaces of crowns showed that the contiguity of the interfaces between the cement and the adjacent materials was incomplete (10). A difference in the localization of slits at the interfaces could be observed depending on the type of cement employed. The extent of these slits with respect to cement type and cement film thickness could not be assessed however, when evaluating sectioned cemented crowns. The purpose of the present investigation was therefore to study the extent of slits in a model system with a linear cement film of controlled thickness.

METHOD

Discs from recently extracted human teeth were cemented together with plane plates of uncast silver/palladium alloy (Hvitstøp, K.A. Rasmussen, Hamar, Norway). The tooth discs were cut from molars embedded in resin (Epofix, Struers Scientific Instruments, Copenhagen, Denmark). Prior to cementation they were polished on carborundum paper no. 400 and 600, brushed lightly with pumice slurry, rinsed and dried with an air blast. The alloy plates were thoroughly sandblasted.

The thickness of the cement film between the tooth and alloy plates was determined

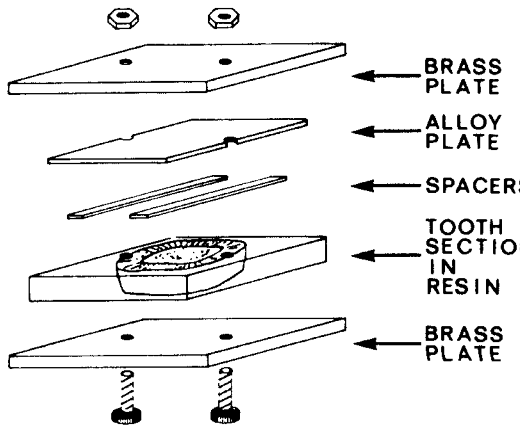
Received for publication, December 27, 1977

by two spacers (Fig. 1) of stainless steel. The spacers and a string of cement between them, were placed on the tooth disc. The tooth disc and alloy plate were pressed together and subsequently fixed between two solid brass plates (Fig. 1, 2).

The described cementation was performed with cements listed in Table 1. Each cement was employed for at least three cementations using spacers of 50 μm, 100 μm and 200 μm thickness. The cementing procedure was finished within 2 min after starting the mix. The specimens were then stored for 10 min in 100 % relative humidity and thereafter placed in distilled water.

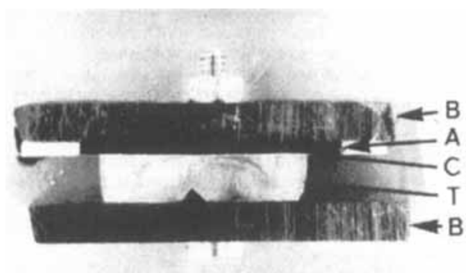
After one week, the specimens were embedded in resin (Epofix) and cut with a diamond blade in two halves between the spacers (Fig. 2). The cut surfaces were then polished on carborundum paper no. 400 and 600, etched with a 1 % solution of phosphoric acid for 10 seconds, rinsed and dried with air. Replicas were then made of the polished surfaces with a light bodied silicone material (Xantopren blue, Bayer, Leverkusen, Germany).

The replicas were inspected in a stereo microscope magnified up to 100 x. They were then coated with a layer of gold and studied in a scanning electron microscope (JEOL – JSMA Scanning Microscope, JEOL Ltd., Tokyo, Japan) (Fig. 3, 4). Projections of the impression material at the cement/tooth or at the cement/alloy interfaces were recorded and their widths and horisontal lengths (extent) were measured using the micrometer system of the microscope. These projections have previously been found to represent slits at the interfaces (10), and the extent of slits was thus recorded as the total length of all projections found at the interface. At least 6 replicas, corresponding to 6 half specimens, were inspected for each cement at each cement film thickness. The mean length of *one interface* was 11 mm. Projections less than 0.02 mm length were not recorded as slits as the differentiation to other "normally" existing pores throughout the cement was difficult.



1

Fig. 1. Tooth-crown model. The cement film is located between the spacers.



2

Fig. 2. Cut and polished surface of the tooth-crown model. A: Alloy plate; B: Brass plate; C: Cement film; T: Tooth section.

RESULTS

The replicas showed that slits occurred at the cement/tooth as well as cement/alloy interfaces in the present tooth-crown model. Large variations were found in the extent and localization of slits. The mean extent of slits in relation to the total length of the interface and the range within each group of specimens, are presented in Fig. 5.

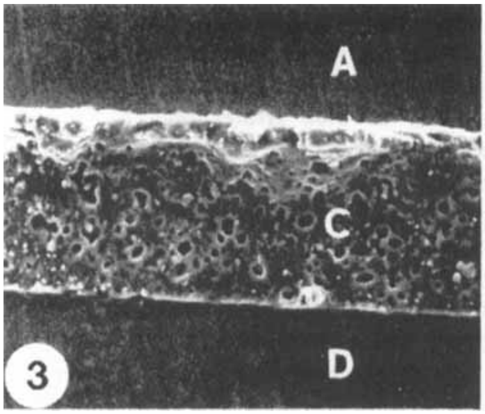


Fig. 3. Replica of zinc phosphate cement film (C) 50 μm thick with projection at the cement/alloy interface. (A: Alloy, D: Dentin). (x 600)

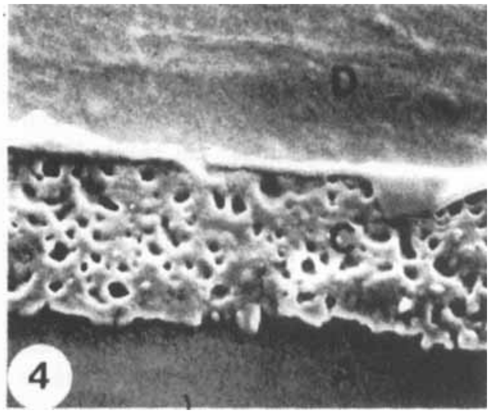


Fig. 4. Replica of zinc phosphate cement film (C) 50 μm thick with projections at the cement/dentin interface. (D: Dentin). (x 500, 30° Tilt.)

The slits varied in width up to 10 μm within each specimen independent of cement type and film thickness. However, a general trend was that projections about 0.02–0.1 mm long (horisontally) were near to 1 μm whereas those longer than 0.1 mm came to as much as 10 μm in width.

The zinc phosphate cement showed a small to moderate extent of slits at both interfaces. Adjacent to the thin cement film (50 μm) the slit formation tended to be larger on the metal side than on the tooth side.

The polycarboxylate cement had a small extent of slits adjacent to the thin cement film, and negligibile at medium (100 μm) and thick (200 μm) films. Two of six specimens with a thin and one with medium cement film thickness showed slits at the cement/tooth interface, but adjacent to thick cement films, slits were only seen at the metal side.

The EBA cement exhibited a small tendency to formation of slits on both sides of a thin cement film, but at medium and thick cement films an increasing extent of slits was found at the cement/tooth interface.

The composite resin cement showed a marked tendency to slit formation independent of cement film thickness. Slits were only observed at the cement/tooth interface.

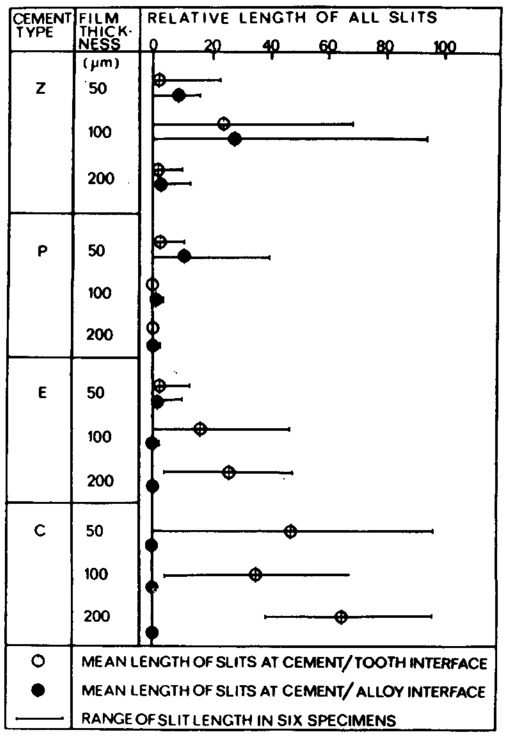


Fig. 5. The extent of slits in relation to the total length of the interface (100) for Z: zinc phosphate cement, P: polycarboxylate cement, E: E.B.A. cement, and C: composite resin cement.

DISCUSSION

The present study showed that the extent of slits varied considerably depending on the type of cement employed. Under the present experimental conditions, the polycarboxylate cement seemed to have a slight tendency to formation of slits while the composite resin cement had a marked tendency independent of the cement film thickness. The zinc phosphate and EBA cements showed a small to moderate extent of slits, but the EBA cement was the only cement where an increased film thickness was accompanied by a marked increase of slit formation.

The differences in the extent of slits correlate with some previous in vivo observations on the sealing effect of these cements. Andrews and Hembree (1) found that leakage occurred with all cements but significantly less for zinc phosphate and polycarboxylate cements than for EBA and resin cements. Brännström and Nyborg (2, 3) found that the composite resin cement provided an unsatisfactory seal against invasion of bacteria from the oral cavity whereas both the zinc phosphate and polycarboxylate cements had good sealing effects. Although a possible antibacterial effect of the cements was not considered, it might be speculated that the difference in sealing effect originates from the difference in the extent of slits, i.e. a greater extent could probably increase the possibility that slits at the deeper part of the interfaces are connected with the oral cavity.

An influence of the cement film thickness on slit formation could only be observed for the EBA cement. This is not in agreement with data on the contraction during setting found in previous studies where the EBA cement was found to have a linear expansion of 0.4 % when setting under wet conditions whilst all the other cements had a linear contraction of 0.4 to 1.0 % (7, 8, 9). It is therefore assumed that the degree of contraction of cements employed in the present study had limited influence on the extent of slits. The variations between the different cements indicate that other factors such as wetting ability and viscosity of the cements are of greater importance for the adaption to adjacent materials, factors which will be of even greater importance in a tooth-crown system where the surfaces are rough and the application of cement more complicated (4). Re-examination of the data on cemented crowns (10) indicates in fact a higher percentage of slits at the interfaces for both zinc phosphate and polycarboxylate cements.

The extent of slits varied considerably within some groups (Fig. 5). It was often found that the replica from one half of the specimen showed a small extent whereas that from the opposite half showed a large extent of slits. The observed extent could have been influenced by the replicating method, as discussed in a previous paper (10). However, it seems reasonable to believe that the above mentioned variations were the result of local variations on the tooth surface which had influenced the wetting process.

The localization of slits correlated well with that found previously (10) where the polycarboxylate cement was the only one which exhibited good contact to enamel and dentin. However, both studies showed that none of the cements had a complete adaptation at both interfaces and that slits occurred that could be of importance not only for the sealing ability of the luting layer but also for the retentive ability, as the area of intimate contact between cement and adjacent materials could be considerably reduced.

Several square millimeters of rough surfaced cement may be introduced in the mouth on cementation of fixed prostheses (5). These will be covered with plaque within a short time (6). Slits at the interfaces, which were often observed at the margins, further increase the area of exposed cement. The presence of slits could therefore influence the rate of dissolution of the cements and lead to an increased amount of plaque retained.

Table 1. *Cements used in the present study*

Type	Name	Manufacturer	Batch no.	Powder/liquied-ratio
Zinc phosphate	De Treys Zinc Cement Improved	De Trey Freres S.A. Zürich, Switzerland	Powder SK1TBK Liquied SE11DK	3 g/ml
Polycarboxylate	Durelon	ESPE GmbH Sefeld/Oberbay, Germany.	Poweder P7512631 Liquied L7609734	1,5 g/g
Reinforced zinc oxide eugenol	Opotow Alumina EBA, Crown & Bridge cement	Teledyne Dental Getz-Opotow Div. Elk Grove Village, Illinois, U.S.A.	092575	7 g/ml
Composite Resin	Epoxylite CBA 9080	Lee Pharmaceuticals, South El Monte, California, U.S.A.	1074BP-2	2 g/g

Acknowledgements. I wish to thank professor dr.odont. K. Dreyer Jørgensen for advice in connection with this study.

REFERENCES

1. Andrews, J.T. & Hembree, J.H. In vivo evaluation of marginal leakage of four inlay cements. J. Prosthet. Dent. 1976, 35, 532–537
2. Brännström, M. & Nyborg, H. Bacterial growth and pulpal changes under inlays cemented with zinc phosphate cement and Epoxylite CBA 9080. J. Prosthet. Dent. 1974, 31, 556–565
3. Brännström, M. & Nyborg, H. Pulpal reaction to polycarboxylate and zinc phosphate cements used with inlays in deep cavity preparations. J. Am. Assoc. 1977, 94, 308–310
4. Eick, J.D., Johnson, L.N., Fromer, J.R., Good, R.J. & Neuman, A.W. Surface Topography: Its influence on wetting and adhesion in a dental adhesive system. J. Dent. Res. 1972, 51, 780–788
5. Silness, J. & Hegdahl, T. Area of exposed zinc phosphate cement surfaces in fixed restorations. Scand. J. Dent. Res. 1970, 78, 163–177
6. Wærhaug, J. Histologic considerations which govern where the margins of restorations should be located in relation to the gingiva. Dent. Clin. N. Amer. 1960, 161–176
7. Øilo, G. Linear dimensional change during setting of a zinc phosphate cement. A methodological study. J. Oral Rehab. 1975, 2, 179–185
8. Øilo, G. Linear dimensional changes during setting of two polycarboxylate cements. J. Oral Rehab. 1976, 3, 161–166
9. Øilo, G. & Ambjørnsen, E. Linear dimensional changes of three luting agents. J. Oral. Rehab. 1977, 4, 395–399
10. Øilo, G. Adaption of luting cements to enamel, dentin an restorative material. Acta Odont. Scand. 1978, 36, 151–158