Effect of cleansing procedures on the retentive ability of two luting cements to ground dentin in vitro

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A method has been described to measure the retention of luting cements to ground dentin *in vitro*. Using a specially designed apparatus, a circular disc of cement was produced on a ground dentin surface of equal diameter. In a universal testing machine a tensile stress was applied to the cement disc pulling it parallel with the dentin surface at right angles to the diamond grooves until separation. The effect of two different cleansing procedures on the retentive ability of two dental cements was investigated. The cleansing procedures were: rubbing ground dentin with Tubulicid® or polishing with wet pumice. The cements studied were a polycarboxylate cement (Durelon®) and a zinc phosphate cement (De Trey's Zink Zement Improved®). The retentive ability of the polycarboxylate cement showed values from six to seventeen times those of the zinc phosphate cement. The retentive ability of zinc phosphate cement was only slightly affected by the two cleansing procedures, while for polycarboxylate cement it was somewhat reduced following rubbing with Tubulicid and greatly improved after polishing with pumice and water.

Key-words: Dental materials; crown and bridge prosthetics

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Retention of fixed dental restorations depend on e.g. area of contact (6), convergence angle of the abutment (5), and inherent properties of the luting agent (12). A chemical bond between cement and tooth substance would greatly enhance the retention of fixed restorations (11). Apart from the polycarboxylate cement introduced by Smith (10), no adhesive properties of the various luting cements have been demonstrated. The creation of additional surface roughness has been advocated to improve the retention of fixed restorations (13). This assumption has been substantiated in an *in vitro* study demonstrating that the retentive capacity of both polycarboxylate and zinc phosphate cement increases with increased surface roughness of dentin and metal (14).

Grinding of dentin produces a smear on its surface (1, 4). Removal of this smear, which may be achieved either by rubbing with Tubulicid® (3) or by polishing with wet pumice (4), has been claimed to improve the retentive ability of both zinc phosphate and polycarboxylate cements (3).

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The aim of the present study was to assess the influence on the retentive ability of a zinc phosphate and a polycarboxylate cement to ground dentin *in vitro* from rubbing the dentin with Tubulicid or polishing it lightly with wet pumice.

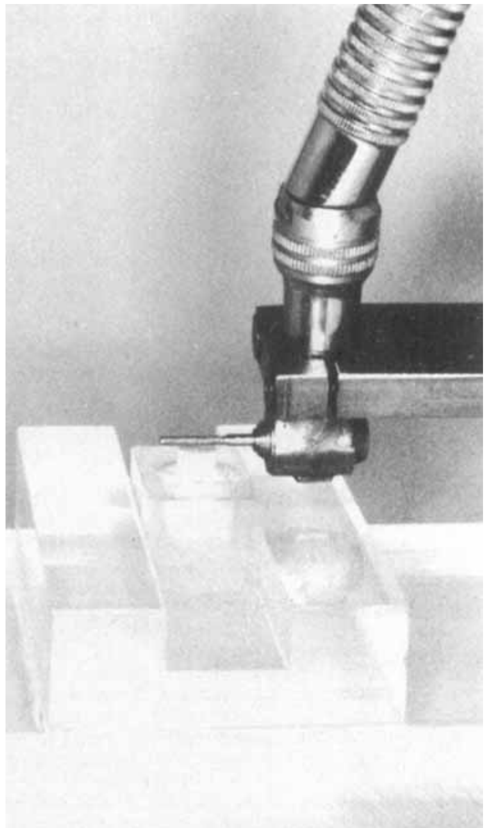

Fig. 1. Specially designed lathe to produce a horizontal dentin surface by means of a cylindrical diamond in an air-turbine. The turbine may be held stationary while the specimen is moved horizontally under the running diamond.

MATERIALS AND METHODS

Extracted, non-carious wisdom teeth were used. The teeth were stored in a 0.2 % chloramine solution. Each tooth was mounted vertically, embedding its root in a Perspex block by means of cold-curing resin.

The occlusal surface of the tooth was cut parallel with the base of the block using a cylindrical diamond bur (Intensiv®, no. 314 S, Hubschmid, Cassarate, Switzerland) in an air turbine mounted in a special lathe (Fig. 1). A dentin cylinder was produced by means of a hollow diamond with an inner diameter of 5 mm (Horico®, no. 61, Hopf, Ringleb & Co., Berlin, W. Germany) held by a straight handpiece in a surveyor. Any excess tooth substance was removed by cutting flush with the upper surface of the Perspex block to the depth of the dentin cylinder wall. Abundant water was applied during cutting. The specimens were kept in an atmosphere of 100 % relative humidity except during testing. Each specimen was used several times, regrinding the top surface of the dentin cylinder in the lathe after each retention measurement.

Surface treatment

Prior to the retention tests the ground dentin surface was subjected to one of the following treatments:

1) rinsed with tap water, and dried with compressed air,
2) rubbed with a cotton pellet soaked in Tubulicid® (Dental Therapeutics AB, Nacka 1, Sweden) for 10 seconds, rinsed with tap water, and dried with compressed air,
3) polished lightly with wet pumice in a Young's rubber cup, rinsed with tap water, and dried with compressed air.

The number of specimens in each group is given in Table 1.

The surface roughness of dried specimens from all three groups was assessed using an electronic surface profile recorder (Perth-O-Meter, Type WB3, Dr. Perthen, Hannover,

Table 1. *No. of specimens in each group cemented with either zinc phosphate or polycarboxylate cement*

	Uncleaned	Tubulicid	Pumice
Zinc phosphate cement	19	19	23
Polycarboxylate cement	18	16	17

W. Germany). The scanning direction was at right angles to the grooves produced by the diamond. For three specimens three scans were made of each, while for one specimen only one scan was made. The scanning length was 1.6 mm. Mean roughness values (R_a) and maximum roughness values (R_{max}) were recorded.

Cementation procedure

The cements studied were: De Trey's Zinc Zement Improved® (De Trey Frères, S.A., Zürich, Switzerland, powder batch no. SK 1 TBK, liquid batch no. SE 1 TDK) and Durelon® (ESPE GmbH., Seefeld/Oberbay, W. Germany, powder batch no. P 7623818 and liquid batch no. L 7515339). The zinc phosphate cement was mixed according to the ISO specification R 1566 at room temperature (23 ± 1 °C) using 1.5 g of powder to 1.5 ml of liquid. The polycarboxylate cement was mixed according to manufacturer's instructions at room temperature, using 1.5 g of powder to 1 g of liquid.

A brass ring was cemented to the ground top of the dentin cylinder by means of a special apparatus to secure correct seating (Fig. 2). To prevent cement from adhering to the apparatus, a plastic foil was inserted between it and the cemented ring. The area of contact between cement and dentin was 19.6 mm^2. A hook had been soldered to the outside of the brass ring. During cementation the ring was orientated with the hook extending at right angles to the grooves made in the dentin by the grinding diamond.

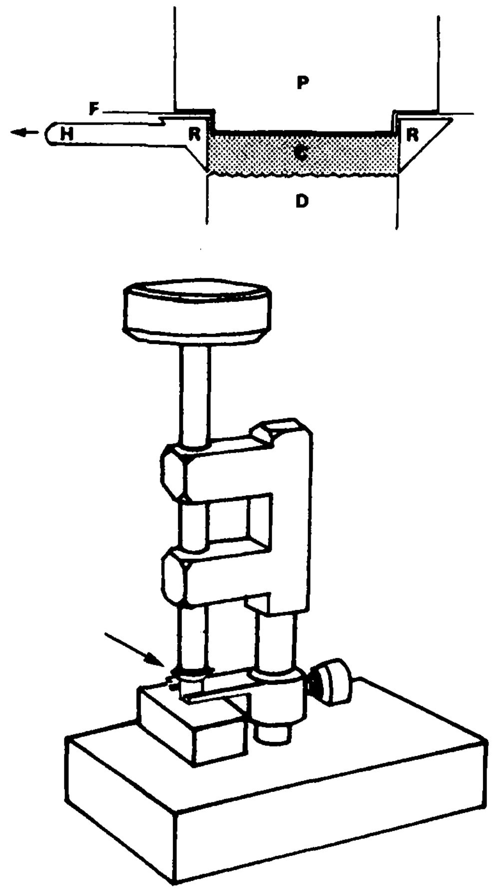

Fig. 2. Schematic drawing of the apparatus used to secure correct seating of the cemented brass ring. Arrow points to the essential part which is shown at higher magnfication above the apparatus. C, cement; D, dentin; F, plastic foil; H, hook (with arrow showing direction of pull); P, piston in apparatus; R, brass ring.

A load of 270 g was applied to the cemented ring for 10 min after which the specimen was placed in a humidifier for 20 min. Excess cement was then carefully removed with a sharp probe, holding the brass ring firmly in place on the dentin cylinder.

Retention measurements

Retention tests were conducted in a Wolpert testing machine (Otto Wolpert Werke GmbH, Ludwigshafen, W. Germany) at 23 ± 1 °C. A *tensile load with a constant* crosshead speed of 20 mm/min was applied to the hook of the cemented brass ring, pulling it parallel with the dentin surface until separation. Since the aim was to measure retention of cement to dentin, and not the shear strength of the cement, only specimens where the break appeared to have occurred at the interface between dentin and cement were included in the results.

Statistics

Differences in surface roughness between the three groups were estimated using the Kruskal-Wallis test (7). In the statistician's opinion the data obtained from the retention measurements were not of a nature that warranted statistical treatment.

RESULTS

The mean (R_a) and maximum (R_{max}) roughness values of the specimens belonging to each group are presented in Table 2. No statistically significant differences were found depending on whether the dentin was uncleaned, rubbed with Tubulicid or polished with pumice.

The force necessary to separate the cement disc from the dentin surface is given in Table 3. The number of observations excluded, varied for each group from zero to five. No systematic differences existed between the two cements. The most striking finding was the great difference in retentive ability between zinc phosphate and polycarboxylate cement. When the dentin was uncleaned the retentive ability of polycarboxylate cement was eight times larger, when rubbed with Tubulicid it was six times larger and when polished with pumice and water is was seventeen times larger than the retentive ability of zinc phosphate cement.

Table 2. *Mean (R_a) and maximum (R_{max}) roughness values in μm in each group*

	Uncleaned Mean ± s.d.	Tubulicid Mean ± s.d.	Pumice Mean ± s.d.
R_a	4.1 ± 1.0	4.6 ± 0.9	4.0 ± 0.6
R_{max}	31.2 ± 4.5	34.8 ± 3.2	32.3 ± 2.8

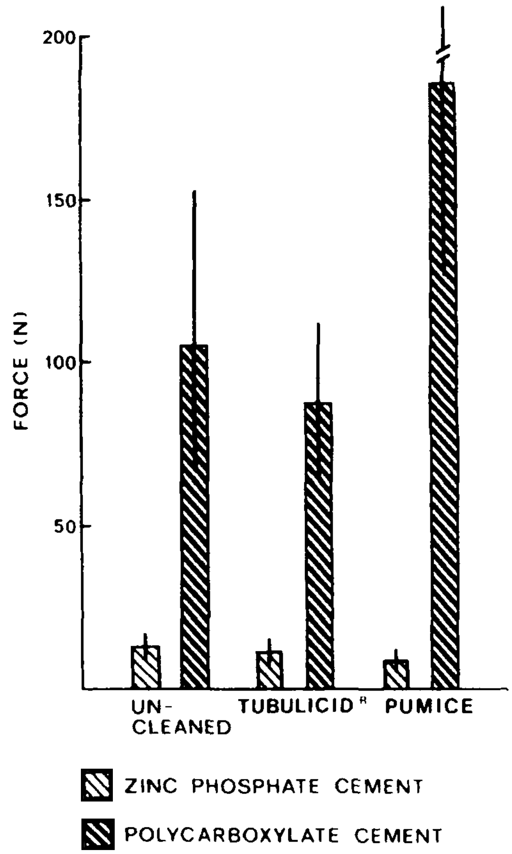

Fig. 3. Mean values and standard deviations for force necessary to rupture the bond between zinc phosphate cement or polycarboxylate cement and differently treated human dentin *in vitro*.

The individual observations varied considerably in all groups with both cements (Fig. 3).

Using cement retention to uncleaned dentin as a reference, the cleaning procedures had different effects on the retentive ability of the two cements. Thus, rubbing

Table 3. *Force in Newton (N) necessary to rupture the bond between cement and dentin*

	Uncleaned Mean ± s.d.	Tubulicid Mean ± s.d.	Pumice Mean ± s.d.
Zinc phosphate cement	13.2 ± 3.9	13.4 ± 3.9	10.5 ± 3.4
Polycarboxylate cement	105.6 ± 36.9	85.9 ± 23.9	185.5 ± 56.9

with Tubulicid did not influence the retention of zinc phosphate cement, while the retentive ability of polycarboxylate cement was somewhat reduced. Furthermore, polishing with pumice and water gave a slightly lower retention value for zinc phosphate cement whereas the retention value for polycarboxylate cement increased considerably (Table 3).

DISCUSSION

It should be noted that individual observations varied widely within each test series. The variations occurred in spite of efforts to avoid errors due to differences in dentin surface structure, cement preparation, and introduction of stresses other than tensile during the test as pointed out by previous authors (8). With this in mind, and considering the fact that occasionally internal cement fractures occurred, it must be accepted that undefined variables other than direct retentive forces between cement and dentin have contributed to the results. Therefore, refined statistical analysis of the present data will hardly help to understand the retentive forces acting between cement and dentin. Nevertheless, some differences in observations were so conspicuous that they may warrant further consideration.

The difference in retentive capacity observed between zinc phosphate and polycarboxylate cement (Fig. 3) is in agreement with previous reports claiming that chemical bonds exist between polycarboxylate cement and tooth structure (10, 2, 9).

For polycarboxylate cement polishing with pumice and water caused a marked increase in retentive ability as compared to uncleaned dentin. This effect is also in agreement with the theory of chemical bonding: Polishing with pumice leaves a clean surface (4) and may thus favour a co-ordination between calcium ions in the hydroxyapatite molecules of the dentin and the polyacrylic acid chains in the cement as suggested by Beech (2). Rubbing with Tubulicid, however, gave somewhat reduced retentive values for the polycarboxylate cement. Again the theory of chemical bonding may provide an explanation: Tubulicid has hydrophobic components which may be left as a film on the dentin surface, preventing or reducing the formation of direct chemical bonds.

For zinc phosphate cement a different pattern of retention to dentin was not unexpected, since it is commonly accepted that chemical bonding does not contribute to retention in this system. It should be noted that although the differences in dentin surface roughness were small, slightly higher values were recorded for Tubulicid-rubbed specimens (Table 2), and these specimens did show slightly higher retention values for zinc phosphate cement (Table 3). This finding corroborates that of Øilo & Jørgensen (14) that retention of zinc phosphate cement depends mainly on mechanical surface interlocking.

This being an *in vitro* study the actual figures obtained for retentive ability should not be considered valid under clinical conditions. Therefore, no conclusions as to which cement is clinically preferable should be drawn from this study alone.

Yet, the present findings may warrant the following conclusions:

1) Ground human dentin retains polycarboxylate cement better than it does zinc phosphate cement.
2) Retention of either cement will not be improved by cleaning the dentin surface with Tubulicid.
3) Retention of polycarboxylate cement can be improved by cleaning the dentin with pumice and water. No similar effect can be expected for zinc phosphate cement.

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REFERENCES

1. Adolph, W. Elektronenmikroskopische Untersuchungen an Dentinoberflächen, die bei Anwesenheit von Wasser, Pressluft und Speichel maschinell bearbeitet wurden. Dtsch. Zahnärztl. Z. 1958, 13, 758–767
2. Beech, D.R. Improvement in the adhesion of polyacrylate cements to human dentine. Br. Dent. J. 1973, 135, 442–445
3. Brännström, M. & Nyborg, H. Cavity treatment with a microbicidal fluoride solution: Growth of bacteria and effect on the pulp. J. Prosthet. Dent. 1973, 30, 303–310
4. Dahl, B.L. Dentine/pulp reactions to full crown preparation procedures. J. Oral. Rehabil. 1977, 4, 247–254
5. Jørgensen, K.D. The relationship between the retention and convergence angle in cemented veneer crowns. Acta Odontol. Scand. 1955, 13, 35–40
6. Kaufman, E.G., Coelho, D.H. & Colin, L. Factors influencing the retention of cemented gold castings. J. Prosthet. Dent. 1961, 11, 487–502
7. Lehmann, E.L. Nonparametrics. Holden-Day, San Fransisco, 1975
8. Phillips, R.W., Swartz, M.L. & Rhodes, B. An evaluation of carboxylate adhesive cement. J. Am. Dent. Assoc. 1970, 81, 1353–1359
9. Rider, M., Tanner, A.N. & Kenny, B. Investigation of adhesive properties of dental composite materials using an improved tensile test procedure and scanning electron microscopy. J. Dent. Res. 1977, 56, 368–378
10. Smith, D.C. A new dental cement. Br. Dent. J. 1968, 125, 381–384
11. Spiro, P. Present status in dental materials. Israel J. Dent. Med. 1975, 24, 4–7
12. Stevens, L. The properties of four dental cements. Austr. Dent. J. 1975, 20, 361–367
13. Tylman, S.D. Theory and practice of crown and fixed partial prosthodontics (bridge). 6th ed. The C.V. Mosby Company, St. Louis, p. 320, 1970
14. Øilo, G. & Jørgensen, K.D. The influence of surface roughness on the retentive ability of two dental luting cements. J. Oral Rehabil. 1978, in press