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THE RELATIONSHIP BETWEEN THE FILM THICKNESS OF ZINC PHOSPHATE CEMENT AND THE RETENTION OF VENEER CROWNS

by

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INTRODUCTION

No investigations seem to have been reported showing the effect of the film thickness of cement upon the retention. In a study published 1961 *Fusayma & Iwamoto* approached the problem. These two authors did not, however, examine the retention between a cemented restoration and preparation, but the friction between two flat surfaces connected with a cement film. Accordingly, their findings demonstrate the influence of cement film thickness upon friction, not upon retention. An essential difference between these two phenomena is that the pressure perpendicular to the cemented surfaces is constant during the measurement of friction, while it is increasing during the measurement of retention.

MATERIALS AND METHODS

The tests were made on preparations and crowns of brass with a Brinell hardness ($5/62^1/_2/30$) of approximately 120 kg/mm^2 and with dimensions as shown in Figure 1. The taper angle was 10°, and the crowns were perforated as illustrated in the figure in order to facilitate escape of excess cement. Preparations and crowns were shaped with a precision lathe at the end of cylindrical brass rods, which were about 5 cm long and 10 mm thick. The excentricity between the tapered and the original surfaces of the rods was in most cases within the limits $\pm 3\ \mu$, and did in no case exceed $\pm 5\ \mu$.

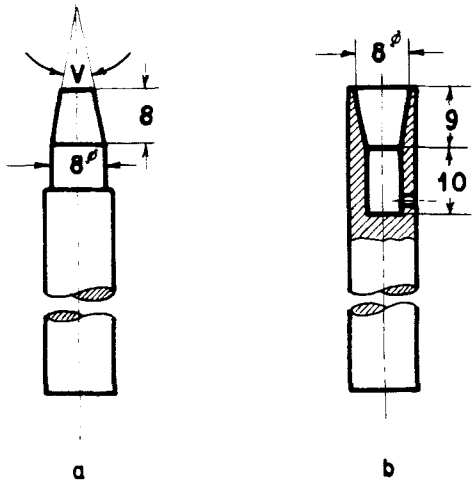

Fig. 1. Schematic drawing of the experimental preparations and crowns. The measurements are given in mm; the angle v is 10°.

For the purpose of standardized roughness the conical surfaces were cut with the same tool at the same rate of speed. No preparation or crown was used for more than one retention measurement.

After cementation of preparation and crown the combined length of the two rods will have increased proportionally to the film thickness of the cement. The increase in length appears in Table I.

Table I

Increase in length of the joined preparation- and crown-rods as varied by the film thickness of the cement

Cement film thickness μ	Increase in length μ
20	229
30	344
40	459
60	688
100	1147
140	1606

The film thickness in the individual tests was established indirectly on the basis of the figures in the right column of Table I and by using the equipment shown in Figure 2. This apparatus essentially consists of a precision

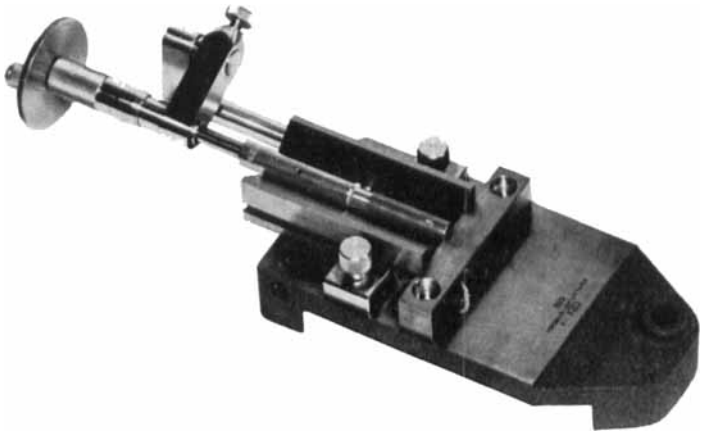

Fig. 2. Equipment for establishment of the film thickness of the cement. The two rods have been placed in the V-block with the preparation inserted in the crown and are pressed against the beam at the end of the V-block by means of the micrometer caliper.

V-block of steel and a micrometer caliper with an accuracy of about $\pm$ 2 μ Before cementation of crown and preparation the two joined rods were placed in the V-block with the end surface of the preparation-rod in contact with a beam at the end of the V-block. The micrometer caliper was then brought in contact with the end surface of the crown-rod and read in this position. To the recorded figure was added the value for the increase in the length of the rods which corresponded to the desired cement film thickness. The rods were then removed from the V-block and separated, the crown was filled with cement, and the rods replaced in the V-block. By means of the caliper the crown was forced down on the preparation until the computed increase in length was obtained. During the compression of preparation and crown and during the initial set the two rods were held in position against the bottom of the V-block with a light pressure of a finger.

The brand used for cementation was Tenet Zinc phosphate cement (Vivadent, Liechtenstein; batch number: powder 543, acid 527) proportioned to give standard consistency as defined in the F.D.I. specification No. 6. Each cementation was carried out with 1.1 g of powder added at one time to 0.5 ml of acid, and spatulation lasted 30 seconds. The crown was then filled with cement, and not later than two minutes after mixing it was placed in the V-block in the calculated position relative to the preparation. Mixing and cementation took place at room temperature (23$\pm$2°C). Ten minutes after mixing the two rods were removed from the V-block and stored one hour in a room at 37°C and 100 % humidity, and then 23 hours in water

at 37°C. Twenty-four ± one hour from cementation the retention was measured by means of a Losenhausen tensile testing machine at a loading rate of 10 kp per second.

The following considerations serve to assess the accuracy of the method. The abovementioned excentricity of ± 3 μ, and maximum ± 5 μ, between the cemented tapered surfaces and the intact cylindrical surfaces means possibility for a maximum variation in the desired cement film thickness of twice the value of these figures. This possibility is not likely to materialize except in rare cases, and the variation can not be classified as a source of systematic error. The micrometer caliper was adjusted to within ± 25 μ corresponding to a variation in cement film thickness of ± 2 μ. It is known from previous studies (*Jørgensen*, 1955) that small variations in the roughness of cemented surfaces has appreciable influence upon the retention. It may be supposed that this condition, in particular, is responsible for the high standard deviation in the experimental data presented below.

RESULTS

The results of the measured retention are presented in Table II and Figure 3. The axial displacement of the crown on the preparation, brought about by the cement film, reduces the retentive area to an increasing degree with increased film thickness. Table II shows the computed retentive area for each individual film thickness, and in accordance with these findings the values obtained for the retention were converted into pond per square millimeter.

Table II

The dependence of the retention upon the thickness of the cement film

Film thickness μ	Number of measurements	Retentive area mm^2	Retention p/mm^2	
			$\bar{x}$	S.D.
20	20	178.3	305.0	82.7
30	25	175.4	291.1	61.6
40	19	172.6	269.3	52.6
60	25	166.8	250.1	47.4
100	25	155.6	257.5	68.8
140	25	144.2	204.4	46.4

A comparison between the individual groups show that the results overlap, even within the groups 20 μ and 140 μ. A comparison by means of Student's t-test between selected groups gave the t-values set out in Table III.

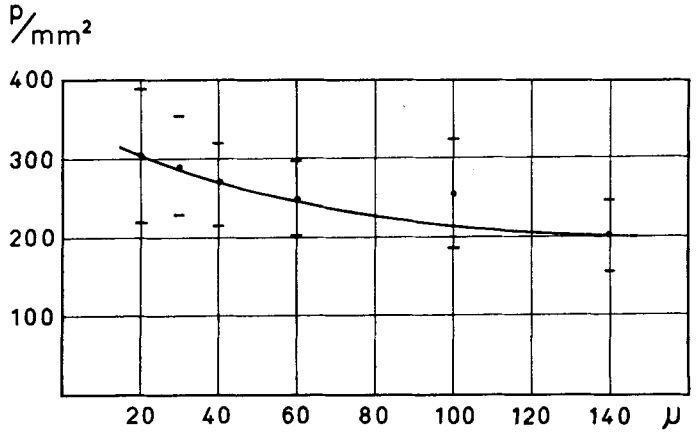

Fig. 3. The relation between cement film thickness and retention. Mean values and standard deviations are noted in the graph.

Table III

Group comparison by Student's t-test

Groups	t-values
20 μ — 30 μ	0.625
20 μ — 40 μ	1.618
20 μ — 60 μ	2.641
20 μ — 100 μ	2.060
20 μ — 140 μ	4.865
60 μ — 100 μ	0.442

The relatively small t-values also showed the moderate influence which variations in the cement film thickness had upon the retention; only the difference between the groups 20 μ and 140 μ was highly significant. The deviation of the 100 μ group from the mean curve was not significant, which is evident from the low t-value between groups 60 μ and 100 μ.

The significance of extreme cement film thickness was investigated in a special series by measuring the retention between crown and preparation after lowering part of the preparation surface 1.5 mm to form a circular, central band. The width of the band was in one test group 2 mm, and in another group 4 mm. Thus the depressed zone in the first group amounted to about 25 % of the conical, retentive preparation surface, and to about 50 % in the second group. The film thickness of the cement between crown and non-depressed preparation surface was in all tests 17 ± 2 μ; it should

be noted that the cement filled up the total depressed area of the preparation. This experimental series was run with crowns and preparations of slightly less surface roughness than in the first reported series. The results of the tests appear in Table IV and Figure 4.

Table IV

The retention on preparations with locally depressed surfaces

Depressed surface area in %		0	25.7	51.4
Retention p/mm²		226.1	206.6	179.2
	S.D.	32.4	53.0	42.4
Reduction of retention in %		0	8.6	20.7

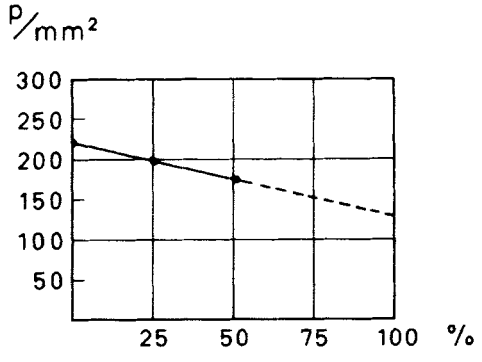

Fig. 4. The effect exerted upon the retention by substituting phosphate cement of standard consistency for parts of the preparation surface. The abscissa indicates the percentage area of the preparation for which cement had been substituted to a depth of 1.5 mm.

The experiments show that substitution of cement for considerable surface areas of a preparation only to a moderate degree reduced the retention of the cemented restoration.

An extrapolation calculation based on the figures in Table IV show that if a 1.5 mm thick cement film obtained from a mix of standard consistency was substituted for the entire preparation surface, the retention would be reduced by about 40 %. This figure accords well with the results in Table II, which show a reduction of 33 % in the retention when the film thickness was increased from 20 μ to 140 μ, and indicates that the effect of the increase in film thickness was reduced with increasing thickness.

SUMMARY

Variations in the cement film thickness had only a moderate influence upon the retention. Defects in the preparation surface filled with phosphate cement mixed to standard consistency, had also only a small effect upon the retention.

RÉSUMÉ

RAPPORT ENTRE L'ÉPAISSEUR DU FILM DE CIMENT AU PHOSPHATE DE ZINC ET LA RÉTENTION DES COURONNES DE REVÉTEMENT

Les variations de l'épaisseur du film de ciment n'ont qu'une influence modérée sur la rétention. Des défectuosités à la surface de la préparation, obturées avec du ciment au phosphate malaxé à la consistance standard, n'ont elles aussi que peu d'influence sur la rétention.

ZUSAMMENFASSUNG

DIE RELATION ZWISCHEN DER FILMDICKE DES ZINKPHOSPHATZEMENTS UND DER RETENTION VON FURNITURKRONEN

Die Ergebnisse zeigten, dass selbst eine bedeutende Steigerung der Dicke des Zementfilmes auf die Retention nur moderaten Einfluss hat. Werden Defekte in der Oberfläche der Präparation durch zur Normalkonsistenz ausgerührten Zement ersetzt, so war die Wirkung auf die Retention auch relativ bescheiden.

REFERENCES

Fusayama T. & T. Iwamoto, 1961: Optimum cement film thickness for maximum shear resistance between teeth and restoration. The Bulletin of Tokyo Medical and Dental University *8:* 147—164.

Jørgensen K. D., 1955: The relationship between retention and convergence angle in cemented veneer crowns. Acta odont. scand. *13:* 35—40.

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