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Luting of vented and etched crowns

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ABSTRACT—The marginal and internal adaptation of luted full crowns prepared using a decreased water/powder ratio were compared after venting, and with the vent sealed, after electrochemical etching. The better fit was obtained by venting. Etching alone did, however, create more passive fitting crowns with enhanced marginal fit.

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Introduction

A frictional fitting crown is in intimate contact with the tooth whereas a passive fitting crown has more spaces and does not resist a vertical withdrawing force. The space between the tooth and the crown has been termed the precementation space.[1] It is the size of this precementation space and the technique of creating it[2-5] that greatly influence the seating of a crown during cementation.

It has been shown that it is advantageous to have an increased precementation space as crowns made using die relief methods have approximately 25 per cent[5] more retention following cementation than crowns constructed on the same unrelieved die. However, it must be noted when increasing the precementation space that retention diminishes approximately one-third as the final cement thickness increases from 20 μm to 140 μm.[6]

Venting,[7-10] of crowns to allow improved seating and marginal fit of a crown on cementation has been used by many researchers to show consistently improved marginal fit over those non-vented crowns. However, not all research[10] has proved the need for venting. Vented crowns have been compared to non-vented crowns with an increased precementation space and showed an

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3 Bassett RW, Status BM. Evaluation of electrochemical milling (stripping) versus etching with aqua-regia. J S Calif Dent Assoc 1966;34:478-83.
4 Fusayama T, Ide K, Hosoda H. Relief of resistance of cement of full cast crowns. J Pros Dent 1964;14:95-106.
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6 Jørgensen KD, Esbensen AL. The relationship between the film thickness of zinc phosphate cement and the retention of veneer crowns. Acta Odontol Scand 1968;26:169-75.
7 Cooper TM, Christensen GJ, Laswell HR, Baxter R. Effect of venting on cast gold full crowns. J Pros Dent 1971;26:621-6.
8 Dimashkieh MR, Davies EH, von Fraunhofer JA. Measurement of the cement film thickness beneath full crown preparations. Br Dent J 1974;137:281-4.
9 Hembree JH, George TA, Hembree ME. Film thickness of cements beneath complete crowns. J Pros Dent 1978;39:533-5.
10 Jones MD, Dykema RW, Klein AI. Television micromeasurements of vented and non-vented cast crown marginal adaptation. Dent Clin North Am 1971;15:663-78.

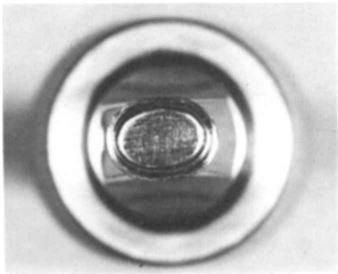

Fig. 1.—An occlusal view of the master die illustrating 0.5 mm shoulder with a 4° convergence angle of the axial walls.

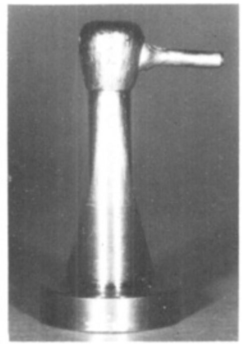

Fig. 2.—The master die and gold alloy crown with cast mesial sprue retained for electrochemical etching.

improved marginal fit.[11] However, recent research[5] has shown that non-vented, die-relieved crowns were of a superior marginal fit to vented, unrelieved crowns.

It is accepted that decreasing the recommended water/powder ratio of the investment increases the setting and thermal expansion of the investment.[12] This causes a corresponding but not uniform enlargement of the mould space.[13] It has been common laboratory practice because of this mould enlargement to decrease the water/powder ratio of the investment in an attempt to achieve passive fitting crowns.

This paper describes the effect of using a decreased investment water/powder ratio and compares venting and electrochemical etching on the marginal and internal adaptation of crowns.

Method

A stainless steel master die was machined to resemble a full crown preparation of a premolar tooth. The axial walls were 6 mm high in an occluso-gingival direction with a 4° convergence angle and a 0.5 mm wide shoulder forming the margin of the die (Fig. 1). Gold alloy Type C crowns were constructed on this die (Fig. 2). Green inlay wax was applied to the die by dipping it into a molten wax bath so as to achieve crease-free internal surfaces. All wax margins were slightly overlapped to aid in the subsequent construction of replicas. Each wax pattern was sprued (10 gauge) on the mesial surface so that the cast sprue could be retained as the anode connection for electrochemical etching but would not interfere with the luting of each crown. Each wax pattern was invested in a gypsum-bonded investment* using 14 ml of distilled water to 50 grams of powder instead of the manufacturer's recommended volume of 16 ml of water. The recommended burnout cycle and casting temperature were followed for the investment and the alloy. The crowns were cast centrifugally.

The acceptability of marginal fit to the master die was assessed by MD using a straight probe, magnifying loops (×2.5) and a microscope with an eye-piece graticule graduated in micrometres. Seventeen crowns were cast and assessed. Crowns were rejected when the marginal gap exceeded 25 μm.

Film fabrication

The satisfactory crowns were luted to the master die with a polyether impression material† so that after set each crown could be removed and a replica made of the film suitable for measurements. This replica technique was similar to that of the McLean and von Fraunhofer[14] *in vivo* study. A separating film‡ was used on the die and crown to minimize tearing of the film.

Replica fabrication

The lute was spread onto the die and injected into the entire crown. The crown was then seated on the die by hand and a 15 kg vertical load applied immediately. The crown with its adhering film was removed from the die fifteen minutes after mixing the lute. The film was rejected if torn. A torn film might not readapt to the crown and might thereby introduce an error in measurement. If the film was intact, an epimine resin§ was injected into the

[11] Bassett RW. Solving the problems of cementing the full veneer cast gold crown. J Pros Dent 1966;16:740-7.

[12] Skinner EW, Phillips RW. The science of dental materials. 6th ed. Philadelphia: WB Saunders, 1967:409-35.

[13] Mumford GM, Phillips RW, Measurement of thermal expansion of cristobalite type investments in the inlay ring—preliminary report. J Pros Dent 1958;8:860-4.

* **Luster Cast.** Kerr Mfg. Co., Romulus, Michigan, U.S.A.

† **Impregum.** ESPE, GmbH, Seefeld, Germany.

‡ **Die-Sep.** J. F. Jelenko & Co., Armonk, New York.

§**Scutan.** ESPE, GmbH, Seefelt, Germany.

[14] McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an *in vivo* technique. Br DentJ 1971;131:107-11.

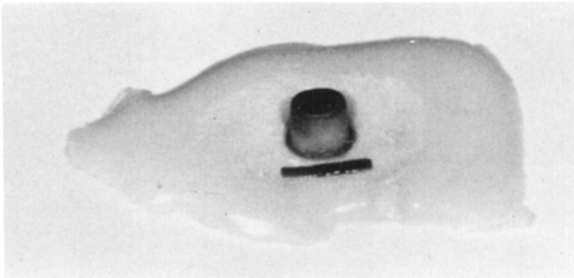

Fig. 3.—A luting film adhering to an epimine base and accompanying mesial marker prior to total embedding in the base.

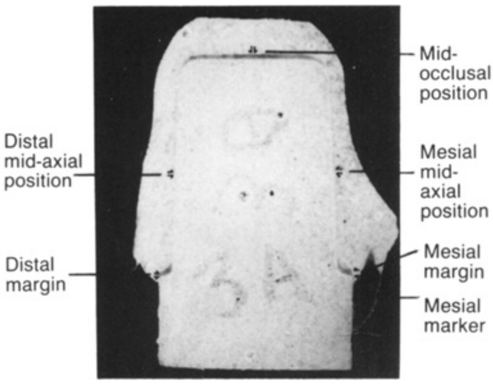

Fig. 4.—A longitudinal section of the polyether elastomeric replica with mesial marker and the points of measurement indicated.

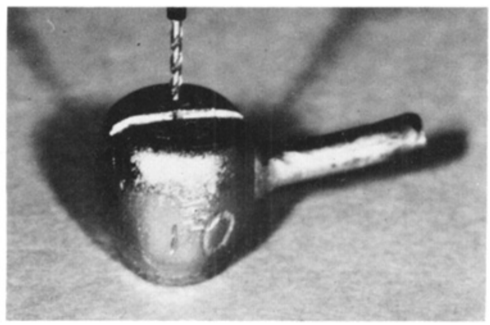

Fig. 5.—The twist drill used in venting the crowns. The occlusal escapeways are seen radiating from the region of the vent hole so that the lute could escape away from the flat plate of the flow device used for luting.

crown. After set of the resin the crown was removed leaving the film of the lute adhering to the resin (Fig. 3). Intact film on the resin substructure was embedded in additional resin. The embedded film was sectioned longitudinally giving 0.2 mm serial sections. The thickness of the film in each section was measured with a microscope and eye-piece graticule (1 μm). Ten measurements were made of each film at five locations: mesial margin, mesial mid-axial surface, mid-occlusal surface, distal mid-axial surface, and distal margin (Fig. 4). The die and crowns were cleaned ultrasonically in an ammoniated detergent solution. Stubborn tags of impression material in the crown were removed with a mixture of 66 per cent (W/W) toluene and 34 per cent (W/W) acetic acid.[15]

[15] Marsden C. Solvents and allied substances manual with solubility chart. London: Cleaver-Hume, 1954.

[16] Darveniza CM. A comparison of the internal and marginal adaptation of full cast crowns as cast, after venting and after electrochemical etching. Brisbane, Queensland: University of Queensland, 1980. M.D.Sc. thesis.

Venting

A vent hole was machined into each crown with a 0.6 mm twist drill as close as possible to the mid-point of the occlusal surface (Fig 5). External escapeways were placed on each side of the vent hole. Each of the vented crowns was individually luted to the die, replicas fabricated, sectioned, and measured. The crowns and die were cleaned as before.

Etching

Electrochemical etching was carried out.[16] The external aspect of each vent hole was restored with a quick-cure resin.‖ Wax was used to prevent ingress of resin internally. The margins and 0.5 to 1 mm of the axial walls closest to the margins were protected with nail polish.[17]

‖ **Duralay.** Reliance Mfg. Co., Detroit, Michigan, U.S.A

[17] Farne JF, Nealey E. The effects of etching on the margins of cast gold restorations. J Pros Dent 1976;35:273-8.

TABLE 1
Individual times of electrochemical etching

Crown number	Type of internal fit 'as cast'	Time of etching (minutes)
1	Passive	3
2	Frictional	5
3	Frictional	7
4	Frictional	9
5	Passive	3
6	Frictional	5
7	Frictional	9
8	Frictional	15
9	Frictional	5
10	Frictional	5

TABLE 2
Internal and marginal measurements (μm) of Crown Number 1 (passive fitting 'as cast')

Position	Number of measurements	As cast		Vented		Etched	
		Mean	s	Mean	s	Mean	s
1	10	93.5	5.6	57.7	7.2	63.6	8.2
2	10	50.7	6.3	49.7	5.8	56.5	11.0
3	10	59.1	3.7	33.1	7.4	31.2	9.1
4	10	53.7	4.7	44.7	5.3	42.5	8.4
5	10	90.5	5.5	100.9	7.8	98.0	5.9
1 and 5	20	92.0	5.7	79.3	22.9	80.9	18.6
2 and 4	20	52.2	5.8	47.2	6.1	49.5	12.0

1 = mesial margin. 2 = mesial mid-axial surface. 3 = mid-occlusal surface. 4 = distal mid-axial surface. 5 = distal margin.

TABLE 3
Internal and marginal measurements (μm) of Crown Number 4 (frictional fitting 'as cast')

Position	Number of measurements	As cast		Vented		Etched	
		Mean	s	Mean	s	Mean	s
1	10	519.7	30.6	92.6	7.7	359.0	11.1
2	10	29.7	6.3	22.1	7.1	42.1	7.1
3	10	634.2	23.9	84.3	8.1	410.1	11.1
4	10	65.8	13.0	17.1	4.9	38.5	5.1
5	10	689.1	18.7	113.6	12.7	304.2	14.0
1 and 5	20	604.4	88.4	103.1	14.8	331.6	30.5
2 and 4	20	47.8	20.7	19.6	6.6	40.3	6.4

1 = mesial margin. 2 = mesial mid-axial surface. 3 = mid-occlusal surface. 4 = distal mid-axial surface. 5 = distal margin.

All crowns were etched until they had a more passive fit. This was achieved progressively by removing the crowns at one minute intervals from the bath and manually assessing passivity of fit. Each etched crown was luted to the die and replicas fabricated, sectioned, and measured.

Results

Of the seventeen crowns cast, ten were accepted. Two of these fitted passively and eight frictionally. The seven rejected crowns were undersized. Table 1 shows the individual times of etching of the ten crowns and the type of initial fit.

TABLE 4
Comparison of means of measurements for the ten crowns

Position	Final film thickness (μm)			LSD test*	Standard deviation
	As cast	Vented	Etched		
1 and 5	316.7	90.3	221.8	82.12	87.40
2 and 4	35.9	22.7	37.5	5.37	5.72
3	305.1	72.1	235.0	74.92	98.55

1 and 5 = mesial and distal margin. 2 and 4 = mesial mid-axial and distal mid-axial surface. 3 = mid-occlusal surface.
* Least difference for significance at the one per cent level.

TABLE 5
Summary of analysis of variance

Position	Source of variation	Degrees of freedom	F test
1 and 5	Venting and etching of 'as cast' crowns	2	16.91*
2 and 4	Venting and etching of 'as cast' crowns	2	20.25*
3	Venting and etching of 'as cast' crowns	2	14.71*

* Significant at one per cent level.

The means and standard deviations of the measurements of the replica obtained from each accepted crown at the different locations were calculated.[16] Figures from one each of the passive and frictional fitting crowns are shown in Tables 2 and 3, respectively.

The means of the measurements and the results of the least difference for significance tests for the treatments for the ten crowns are presented in Table 4. The results of the analysis of variance show a significant effect ($p<0.01$) between the treatments performed on the as cast crowns (Table 5).

The means of Positions 1, 5, 2, and 4 were compared to determine if crowns tilted during luting.[18] The crown was considered to have tilted when $1>5$ as $2<4$ or $1<5$ as $2>4$. It was found that Crown 1 (Table 2) and 5 tilted during luting in the as cast stage. Crowns 1, 2, 3, 4 (Table 3), 6, and 7 tilted after venting stage. Crowns 1, 5 and 6 tilted during the etched stage.

Discussion

The film thickness of the crowns at the margins was significantly different ($p<0.01$) with the smallest film occurring after venting, followed by etching and as cast (Tables 2, 3, 4). These results are accounted for as escape of the lute in the vented crowns was possible through the vent as well as at the margins.

Mid-axial and mid-occlusal surface measurements were significantly different ($p<0.01$) comparing vented, with etched and as cast crowns (Tables 2, 3, 4). However, there was no difference between etched and as cast crowns. This occurred because of two interacting factors: the etched crowns seat axially further than the as cast crowns, and the precementation space was greater for the etched crowns. It was observed that the mean of the mid-axial films of the as cast crowns etched to produce passivity was 37.5 μm which is within the 'safety retention limit' of 140 μm mentioned by Jorgensen.[6]

The phenomenon of crowns tilting following luting has been reported previously by Jorgensen;[18] it was more noticeable with vented crowns. This effect may have been a result of the preferential flow of lute from axial walls with a larger precementation space to the vent which may not have been precisely centred.

In these experiments, the surface of the master die had to be smooth and polished to prevent the impression material tearing. Such a surface allowed intimate contact of the wax in construction of the crowns and produced extremely well adapted wax patterns. In contrast, wax patterns produced on 'rough' surfaced clinical dies generate smears and streaks[19] of the wax with disengagement possibly resulting in more precementation space. Hence, wax patterns produced on this die were sensitive to all casting variables such as casting surface roughness[19] and non-uniform mould enlargement.[13] This probably explains the production of mostly frictional or undersized internal fitting crowns to seat on an unrelenting stainless steel die despite the use of a reduced water/powder ratio.

[18] Jørgensen KD. Factors affecting the film thickness of zinc phosphate cements. Acta Odontol Scand 1960;18:479-90.

[19] Ostlund LE. Improving the marginal fit of cast restorations. J Am Acad Gold Foil Oper 1974;17:56-65.

The results of luting a passive fitting (as cast) crown are illustrated in Table 2. In this case, the passive as cast crown had no need of venting or etching as only a small improvement at the margins could be demonstrated. The results of luting an extremely tight, internal fitting crown are illustrated in Table 3. In this case, the procedure of venting was clearly required to improve the internal and marginal fit.

An increase in the setting and thermal expansion of the investment occurs with a decrease in the water/powder ratio.[12] This is one technique that can be used to increase the mould dimensions. However, the present results would indicate that altering the water/powder ratio will not always create a passively fitting crown. Factors other than decreasing the water/powder ratio of the investment must be considered as a cause of increase in the precementation space to produce passive fitting crowns as cast. Such factors could have been related to the deformability of the wax pattern as affected by: the number of times the pattern was removed from the die before investing; the surface roughness of the die; the hardness of wax and the length and taper of the preparation.

Conclusions

1. Decreasing the manufacturer's water/powder ratio of the investment produced a greater proportion of frictional fitting crowns with passive fitting crowns.
2. The passive fitting crowns created by electrochemical etching resulted in a significantly improved marginal fit compared with the 'as cast' crowns.
3. The smallest lute film thickness at the mid-occlusal surface, mid-axial surfaces and the margins was obtained by venting.
4. The phenomenon of crown tilting was most frequent with vented crowns.

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