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Experimental marginal leakage around Isocap® and Compocap S® restorations

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SUMMARY

Experimental marginal leakage around Isocap[R] and Compocap S[R] restorations placed with or without prior etching of cavity margins was compared using a fluorescent dye technique. All of the restorations examined leaked to some extent. No statistically significant differences were found between the marginal leakage of the Isocap[R] and Compocap S[R] restorations. Statistically significant differences in experimental marginal leakage were found between the etched and unetched preparations. Restorations placed in conjunction with the etching technique displayed less experimental marginal leakage.

OPSOMMING

'n Fluoresserende kleurstof is gebruik om eksperimentele randlekkasie om Isocap[R] en Compocap[SR] herstellings met geëiste en ongeëiste kawiteitsrande te ondersoek. Al die herstellings het 'n mate van lekkasie getoon. Geen statisties noemenswaardige verskille is tussen die randlekkasie van die Isocap[R] en Compocap[SR] herstellings gevind nie. Statisties noemenswaardige verskille is wel tussen die geëtste en ongeëtste preparate gevind. In gevalle waar die geëtste tegniek gebruik is het herstellings minder eksperimentele randlekkasie getoon.

INTRODUCTION

Clinical marginal leakage may hasten the breakdown and dissolution of certain biomaterials and tooth substance and may cause tooth or restoration discolouration, post-operative tooth sensitivity, pulpal inflammation and dental caries with their sequelae. However, the clinical significance of experimental marginal leakage remains speculative as it demonstrates a potential, but not a clinical reality (Roydhouse, 1968). This does not preclude the possibility that the best seal against an experimental penetrant may be the best seal against clinical marginal leakage (Swartz and Philips, 1962).

Isosite* is a direct filling resin marketed as a hand-mixed, two paste system (Isopast[R]), an ultra-violet activation system (Isolux[R]) and a normal (Isocap — N[R]) and a syringe-capsulated (Isocap[R]) system. Isosite, which is a microfill restorative material, contains organic submicron particles in a matrix based on a modified Bowen resin. Although microfill restorative materials can be polished to a higher gloss than the conventional composites, they have a relatively high coefficient of thermal expansion (Braden, 1979 and Dogan, Van Leeuwen and Norris, 1980).

Nelson, Wolcott and Paffenbarger (1952) have emphasized the importance of a material's coefficient of thermal expansion with respect to marginal percolation. However, Asmussen and Jφrgensen (1978), have stated that, provided that a relatively small wall-to-wall polymerization contraction and adequate expansion due to water absorption occurs, temperature changes within realistic limits will not influence the marginal integrity.

The manufacturers of Isosite (Technical Information 1977*) have claimed that the coefficient of thermal expansion of a dental material evaluated as an isolated factor does not predict the marginal seal in a clinical situation. They also claimed that an essential factor in producing a marginal seal is the controlled water absorption of a dental restoration in relation to its polymerization shrinkage. In other words, if the water absorption over-compensates for the polymerization shrinkage, as realised in Isopast[R], the restorative material will produce in the cavity an effect similar to a cork in a bottle-neck. The restoration is thus firmly retained in the cavity because the over-compensating water absorption produces a tight marginal seal by adequate expansion.

The purpose of this study was to determine and to compare the *in vitro* experimental marginal leakage of an Isosite syringe-capsulated system, Isocap[R]* (selected for ease of mixing control) and a similar syringe-capsulated conventional composite system, Compocap S[R]*.

Vivadent, Schaan, Leichtenstein.

*Vivadent, Schaan, Leichtenstein

MATERIALS AND METHODS

Unblemished, non-carious, extracted human canine teeth were selected from a batch that had been stored for several months at - 5 °C. The teeth were examined under a binocular operating microscope** (at a magnification of X 16) and the visible, fracture-free regions on the middle third of the labial surface in which the cavities could be prepared were outlined with pencil. Any teeth presenting fractures in the middle third of the buccal regions were discarded. Oval cavities (approximately 4 mm x 2½ mm) with the bases in the outer third of the dentine and with bevelled margins (approximately 0.5 - 1,0 mm wide) were cut within the outlined labial regions using a water-cooled tungsten carbide fissure bur *** in an air turbine handpiece. The bur was changed after every 8 cavities to ensure that all cavities were cut with a sharp instrument. The preparations were then examined with the operating microscope at a magnification of X16 and specimens with fractures associated with the cavity margins were discarded.

Each of two operators produced 40 satisfactory cavities in this manner. The 80 prepared teeth were pooled and stored at room temperature in a screw top jar on cotton wool saturated with distilled water containing a few granules of thymol disinfectant. Fifty teeth were randomly selected, thoroughly washed and dried with an air and water syringe before being etched for 60 seconds. Equal numbers of etched cavities were thoroughly washed and dried and alternately filled according to the manufacturer's instructions with Compocap S[R] and Isocap[R]. The remaining 30 specimens were thoroughly washed and dried and their cavities alternately filled with the two restorative materials, without any prior etching. A primer (contact resin) was not applied to any of the preparations. All the specimens were then stored at room temperature for 24 hours in distilled water containing a few granules of thymol, before being polished with a recommended polishing kit*.

The polished specimens were then placed in a thermal cycling machine**** and subjected to cyclic temperature changes by alternate immersions in water at 15 °C and 45 °C employing immersion times of 45 seconds. There were 24 runs of thermal cycling and each specimen was exposed to a mean of 2 408 immersions (S.D. 116).

After each thermal cycling run, the batch of specimens was dried with compressed air and the tooth surfaces around the restorations painted with two applications of varnish, leaving only the restorations and an area of about 1 mm width around their margins free of varnish. The specimens were then immersed in an aqueous fluorescent dye + for 24 hours at room temperature. After removal from the dye solution, the specimens were thoroughly washed in running water and the tooth crowns then scraped clean of varnish. The specimens were thereafter embedded in clear polyester++ resin for subsequent sectioning. Two transverse parallel sections were cut at 100μm intervals at the junction of the middle and outer thirds of the restorations, using a water-cooled, lowspeed saw+++. The sections were mounted in glycerine and examined by transmitted ultra-violet fluorescent microscopy++++

Damaged sections were discarded. Each investigator independently graded the observed marginal leakage according to the following scoring system (Fig. 1.):

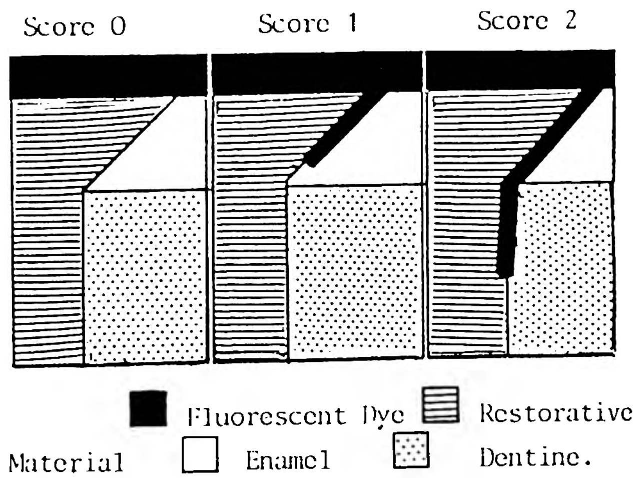

Fig. 1 Experimental Marginal leakage scoring system.

0 = No experimental marginal leakage — no dye penetration between the restoration and cavity wall.
1 = Moderate marginal leakage — no dye penetration beyond the dentino-enamel junction.
2 = Severe marginal leakage — dye penetration beyond the dentino-enamel junction.

The scoring system was applied to two sections per tooth specimen, and the highest score obtained from each specimen was adopted as the degree of marginal leakage. Inter- and intra-examiner variations were assessed after 50 per cent of the specimens had been re-examined. No statistically significant differences were found.

RESULTS

A total of 13 specimens were discarded because the specimens were unsuitable for examination owing to sectioning errors. On examination, the remaining 67 restorations all showed dye penetration, indicating leakage. Thus none of them displayed scores of zero. The results are tabulated in Table 1 and were subjected to statistical analysis using the Fisher exact probability test and the Chi square test where applicable. A p value of < 0,01 was selected as the level of statistical significance. The number of restorations exhibiting moderate marginal leakage (Score 1) was compared against the number of restorations demonstrating severe marginal leakage (Score 2). No statistically significant differences were found between the experimental marginal

** Carl Zeiss, Oberkochen, Germany.
*** Jota Carbide Bahrer Burs, Frases Freasas CFG21 014.
****Mediquip Engineering, P.O. Box 56360, Pinegowrie, Randburg, R.S.A.
+ Black Ray, Ultra-Violet Products, Inc. San Gabriel, California, U.S.A.
++ Jacksons Fibreglass (Pty) Limited, Johannesburg, R.S.A.
+++ Isomet, Buehler Ltd. 2120 Greenwood Street, Evanston, Illinois, U.S.A.
++++ Univar, Reichert, Vienna, Austria.

Table 1 Results of experimental marginal leakage around etched and unetched Compocap S® and Isocap® restorations.

	SCORE:	0		1		2	
Material	Etched or unetched	n	%	n	%	n	%
Compocap S[R]	etched	0	0	13	62	8	38
	unetched	0	0	1	9	10	91
Isocap[R]	etched	0	0	9	43	12	57
	unetched	0	0	1	7	13	93

leakage around the Isocap[R] and Compocap[R] restorations.

However, statistically significant differences were found between the etched and unetched specimens. Restorations placed in conjunction with the etching technique displayed less marginal leakage.

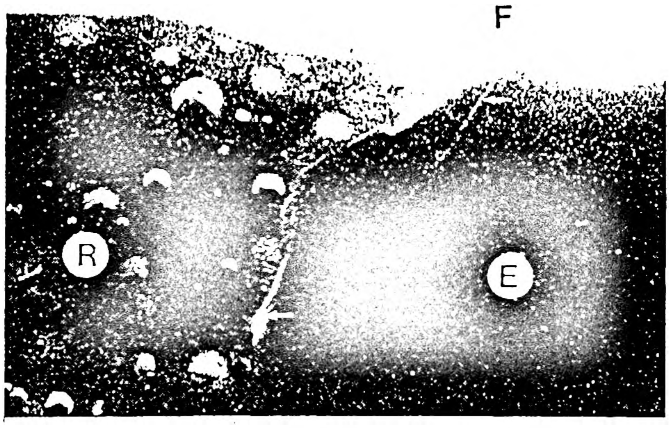

Fig. 2 Experimental Marginal leakage of fluorescent dye (F) between a restoration (R) and enamel (E). The fluorescent dye has also penetrated into an enamel fracture. x 50.

DISCUSSION

Enamel fractures, (Fig. 2) possibly produced during mechanical cavity preparation, thermal stressing (Asmussen 1974), polymerization shrinkage or elastic hysteresis (Jørgensen, Asmussen and Shimokobe, 1975) may account for the fact that all the restorations leaked.

The results appear to advocate the use of an etching technique as a significant difference ($p < 0{,}01$) was found between resotrations placed in etched and unetched preparations. This conclusion is supported by numerous studies including those of Retief (1973), Baharloo and Moore (1974), Eliasson and Hill (1977) and Dogan *et al* (1980). Unetched cavity preparations filled with either type of restorative material permitted more leakage than restorations placed in conjunction with the etch technique.

Another technique advocated in order to limit marginal leakage, other than acid etching, is the use of a primer resin (also referred to as an intermediary resin). Although the acid etch technique is widely accepted, the use of a primer resin is controversial. Recent experimental marginal leakage studies on microfill restorative materials have however supported the use of a primer resin (Dogan *et al* 1980; Valcke and Austin 1980).

Although Eliasson and Hill (1977) stated that the designs of cavosurface margins have little influence on marginal leakage patterns, the use of a bevel has been advocated (Bjorvatin, 1975; Eriksen and Buonocor, 1976; Sockwell 1976). A bevel may increase the enamel surface area which comes into contact with the restorative material that mechanically bonds to it. The use of a restorative-feather-edge technique (Buonocore, Sheykholeslam and Glena, 1973) may also provide an increased enamel surface area whilst also sealing fractures associated with the cavity preparation. Although the bevelled preparation and/or restorative-feather-edge technique appear to be theoretically sound, there are practical limitations especially on the cervical margins of restorations where the tooth enamel is thin (if still present) and the gingival tissue is close to the preparation. Øilo and Jørgensen (1977) showed that bevelled margins display a reduced number of restorations with fractures in enamel. Thus bevels may not only increase enamel — restorative material interface areas, but in some tooth regions may reduce the number of fractures which result along the cavity margins.

Isocap[R] which has a relatively high coefficient of thermal expansion has performed satisfactorily in clinical studies (Bryant, Rees and Ross, 1979 and Christensen and Christensen, 1980). This may be due to the low thermal diffusity of this resin which reduces the effects of thermal stresses (McLean, 1979; Braden, 1979), the sufficient expansion due to water absorption (Bryant *et al* 1979) and /or other manipulation and clinical factors.

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REFERENCES

Asmussen, E. (1974) The effect of temperature changes on adaptation of resin fillings I. *Acta. Odontologica Scandinavica*, **32**, 161-171.

Asmussen, E. & Jørgensen, K.D. (1978) Restorative resins: Coefficient of thermal expansion — a factor of clinical significance ? *Quintessence International*, **9**, 79-82.

Baharloo, D. & Moore, D.L. (1974) Effect of acid etching on marginal penetration of composite resin restorations. *Journal of Prosthetic Dentistry*, **32**, 152-156.

Braden, M. (1979) Developments in the science and technology of restorative materials. *British Dental Journal*, **146**, 318.

Bryant, R.W., Rees, F.T. & Ross, I.D. (1979) Clinical evaluation of a restorative resin with organic filler. Preliminary report and discussion. *Australian Dental Journal*, **24**, 402-407.

Buonocore M.G., Sheykholeslam, Z. & Glena, R. (1973) Evaluation of an enamel adhesive to prevent marginal leakage: An in vitro study. *Journal of Dentistry for Children*, **40**, 119-124.

Bjorvatin, K. (1975) The use of acid etch technique in paedodontics In Scandinavia: Clinical and technical studies. In *The Acid Etch Technique* ed. Silverston L.M. and Dogon IL. pp. 230-237. Minnesota : North Central Publishing Co.

Christensen, R.P. & Christensen, G.J. (1980) In vivo comparison of Composite and Microfill resin: a two year report. *Journal of Dental Research*, **59**, Abstract 219 page 322.

Dogan, I.L., van Leeuwen, M.J. & Norris, D. (1980) Thermal cycling studies of new microfill restorative materials in Ca^{45} isotope solutions. *Journal of Dental Research*, **59**, Abstract 213 page 321.

Eliasson, S.T. & Hill, G.L. (1977) Cavosurface design and marginal leakage of composite resin restorations. *Operative Dentistry*, **2**, 55-58.

Eriksen, H.M. & Buonocore, M.G. (1976) Marginal leakage with different composite restorative materials in vitro. *Journal of Oral Rehabilitation*, **3**, 315-322.

Jørgensen, K.D., Asmussen, E. & Shimokobe, H. (1975) Enamel damages caused by contracting restorative resins. *Scandinavian Journal of Dental Research*, **83**, 120-122.

McLean, J.W. (1979) The future of restorative materials. *Journal of Prosthetic Dentistry*, **42**, 154-158.

Nelson, R.S., Wolcott, R.B. & Paffenbarger, G.C. (1952) Fluid exchange at the margins of dental restorations. *Journal of the American Dental Association*, **44**, 288-295.

Øilo, G. & Jørgensen, K.D. (1977) Effect of bevelling on the occurance of fractures in the enamel surrounding composite resin fillings. *Journal of Oral Rehabilitation*, **4**, 305-309.

Retief, D.H. (1973) Effect on conditioning the enamel surface with Phosphoric Acid. *Journal of Dental Research*, **52**, 333-341.

Roydhouse, R.H., (1968) Penetration around the margins of restorations: 2. Nature and significance. *Journal of the Canadian Dental Association*, **34**, 21-28.

Sockwell, C.L. (1976) Clinical evaluation of anterior restorative materials. *The Dental Clinics of North America*, **20**, 403-422.

Swartz, M.L. & Phillips, R.W. (1962) Influence of manipulative variables on the marginal adaptation of certain restorative materials. *Journal of Prosthetic Dentistry*, **12**, 172-181.

Valcke, C.F. & Austin, J.C. (1980) The Effectiveness of a Primer (contact resin) in Diminishing the Marginal Leakage of a Direct Filling Resin (Isopast). *Journal of the Dental Association of South Africa*, in press.

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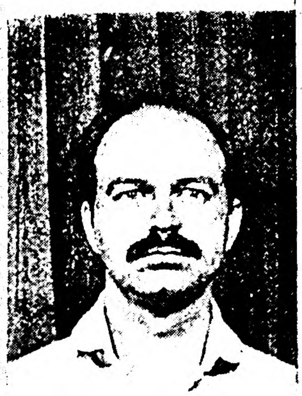

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