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Operative Dentistry publishes articles that advance the practice of operative dentistry. The scope of the journal includes conservation and restoration of teeth; the scientific foundation of operative dental therapy; dental materials; dental education; and the social, political, and economic aspects of dental practice. Review papers and letters also are published.

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EDITORIAL

One More for Professor Hamilton

The last issue of *Operative Dentistry,* Volume 10, Number 4, was something to behold. It was the first issue in which color prints were used. More importantly, it was also the last to be published with Dr Alexander Ian Hamilton as its editor and was, secretly, printed as a special tribute to Dr Hamilton. That issue was formatted and printed in the usual manner with the galleys and blue line carefully reviewed, scrutinized, and corrected by Dr Hamilton, while the tributes to him were printed without his knowledge. It took a great deal of planning on the part of Joan Manzer and Nancy Neyens, of our editorial staff, and Dr J Martin Anderson, managing editor, to assemble this past issue and keep the tribute to Ian a closely guarded secret. Surprisingly, the plot succeeded! As the issue was being mailed to the subscribers, Ian picked up a copy at Mailing Services on his way home from work and saw the tribute for the first time. That special recognition for Ian seemed to be the best way that we could show our appreciation for his many years of dedicated service.

Ian has many friends around the world who know him well and have personal knowledge of the significant contributions he has made over his long career. On the other hand, many readers of the Journal only recognize him for his editorial efforts. Although the past issue alluded to many of his accomplishments, it seems only fitting that we use this space to tell you about A Ian Hamilton, the man.

Born on August 16, 1915, to Dr and Mrs Frederick Hamilton of Winnipeg, Canada, he was destined to follow in his father's footsteps and study dentistry. He attended the University of Manitoba at Winnipeg where he took his premedical training, 1931–1932. He then matriculated at the University of Toronto in 1932, completing his DDS with honors in 1936. Other educational endeavors included the completion of a BA in 1953 and an MA in economics in 1958, both from the University of Washington.

The crown of his educational efforts is the PhD he received in Anatomy in 1968 from the prestigious University of London, England.

As a college student he was the Canadian national pole vaulting champion and received many medals in track and field for his athletic prowess, particularly in high hurdles and in sprinting. As one can see from his studies and other activities, his interests in life are varied, which perhaps explains the broad background of information and data he carries with him in his everyday travels.

Following graduation from dental school, he was in private practice in Winnipeg, where he remained until 1939 when the interruption of World War II led him into active duty in the Canadian Dental Corps. He saw action in the European theater, then returned to private life and dental practice in Victoria, BC, Canada. He remained in this practice from 1946 to 1949 when Ian and his wife Mary, the former Mary Brownley Garrison, moved to Seattle as Ian accepted a faculty position as instructor in operative dentistry at the University of Washington.

Since his move to Seattle Ian has spent 36 years of his life teaching, conducting research, studying, and providing service. His research efforts were concentrated in the study of implants and in the epithelium of the oral cavity. Not only is he an avid reader of scientific dental publications, he has also kept abreast of the field of economics and literature in general. He maintains the finest reprint collection imaginable, on a wide variety of subjects. We are all familiar with his editorial prowess. The number of papers he has published over the span of his career is significant. How many authors in dentistry do you know that have published scientific papers in such prestigious journals as *Science* and *Nature*?

Our profession can be proud of the many years of distinguished service he has unselfishly given. We are all benefactors of his wit and wisdom. He is now professor emeritus, retired officially as of December 31, 1985, from the University and from the Journal.

His tenure as editor of ten volumes of the Journal, plus an additional two years organizing and creating it, has earned him the respect and admiration of many individuals the world over. His editorial skills, coupled with his dedication to perfection, place him in a class of his own. He made the Journal what it is today. To follow him as its newly selected editor is an honor. I may be following him, but I will never replace him!

Editors of scientific journals are said to be continually walking a tightrope. They must encourage authors, offer them guidance, reject more papers than they publish, maintain quality and integrity, and somehow keep everyone happy. It is asking the impossible. I have witnessed the agonizing experience that he has gone through in dealing with authors and referees. Being an editor must certainly have its joys, including the potential of a sense of satisfaction for a job well done. On the other hand, the hardship that an editor can face is known only by those who have experienced it. H L Mencken summed up his idea of what it is like to be an editor: "I note what you say about your aspiration to edit a magazine. I am sending you by this mail a six-chambered revolver. Load it and fire every one into your head. You will thank me after you get to Hell and learn from other editors how dreadful their job was on earth." (Day, 1979)

Professor Hamilton was, and is, a survivor. He can take great pride in his achievements, particularly the Journal. In conclusion, the following poem (Anonymous, 1958) is offered as a word of thanks:

THE EDITOR'S PASSPORT

The Editor stood 'fore the Heavenly Gate,
His features pinched and cold.
He bowed before the Man of Fate,
Seeking admission to the fold.
"What have you done," St Peter asked,
"To gain admission here?"
"I was the Journal's editor, Sir,
For many a weary year."
The Pearly Gates swung open wide
as Peter pressed the bell.
"Come in and choose your harp," he cried;
"You've had your share of hell!"

Ian and Mary, we wish you well in the years to come. We know that you are looking forward to having the time to do the many things which you have always wanted to do. We are proud to have been your friends. Good luck!

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ORIGINAL ARTICLES

Surface Porosity of Stone Casts Made from Vinyl Polysiloxane Impression Materials

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JOHN C MAYER • KHAMIS HASSAN

Summary

Delaying for various lengths of time the pouring of casts from impressions made with the vinyl polysiloxanes, Reprosil and Reflect, showed that porosity of the surface of the casts is lowest when they are poured within 15 minutes or after 24 hours.

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INTRODUCTION

The vinyl polysiloxane, or addition type of silicone, impression materials are being increasingly used by dentists. While the mechanical properties, accuracy, and ability to reproduce fine detail of these materials are comparable to those of other elastomeric impression materials, the polysiloxanes are superior in their handling characteristics and dimensional stability over extended periods of time (Eames & others, 1979; Farah, Clark & Ainpour, 1981; Lacy & others, 1981). In fact, these two factors appear to be the main advantages of using polysiloxanes in clinical practice. Empirical observations made by clinicians have indicated that casts of die stone made from some of these impression materials often exhibit porous surfaces (Phillips, 1982; Baum & McCoy, 1984). Such porosity is said to be caused by evolution of hydrogen gas during the setting of these materials. A common procedure employed by clinicians to overcome this problem is to delay the pouring of the casts for several hours. Although the dimensional stability of these materials is excellent, this technique of delayed pouring has a potential for producing inaccuracies in the casts, especially when the conditions for storing the impression are not favorable.

A survey of the literature yielded no data concerning the length of the delay that should be employed before pouring the casts. This investigation, therefore, was designed to determine the optimum delay in pouring casts that would result in minimal porosity of the surface.

MATERIALS AND METHODS

Two polysiloxane impression materials, Reprosil (L D Caulk Division, Milford, DE 19963, USA) and Reflect (Kerr, Division of Sybron Corp, Romulus, MI 48174, USA) were selected for this investigation. Impressions of a posterior quadrant of the mandible of a Dentoform (Columbia Dentoform Corp, New York, NY 10010, USA) were made by using a disposable tray of acrylic (Kerr, Division of Sybron Corp). The Dentoform model consisted of teeth of a rigid polymer and a mucosal surface of rubber. Five impressions were made with each material for each interval of delay and a single cast was produced from each impression. The impressions were stored in air at room temperature (22±2 °C) until they were ready for the pouring of the casts.

Velmix die stone (Kerr, Division of Sybron Corp), mixed with water in the proportion recommended by the manufacturer, was spatulated by hand and vibrated into the impression. The casts were poured at intervals of 0, 15, and 30 minutes, and 1, 2, 4, 8, 12, and 24 hours after the impressions had been removed from the model. The casts were observed at a magnification of 10X with a stereo microscope, the eyepiece of which was fitted with a measuring grid.

The pores at five locations on the facial aspects of the casts, from the area of the canine to the second molar, were counted. At each location the pores on the surface of the tooth and on the surface of the mucosa were counted separately. Some casts, which were irrevocably damaged during their removal from the impressions, were discarded. For some of the experimental intervals, therefore, there were less than five, but at least three, casts.

Nonparametric analysis of variance and Student's t-test were used for statistically evaluating the differences between the number of pores formed by the two materials at different locations and for different intervals of time.

RESULTS AND DISCUSSION

Examples of surface porosity are illustrated in Figure 1. The overall mean numbers of pores

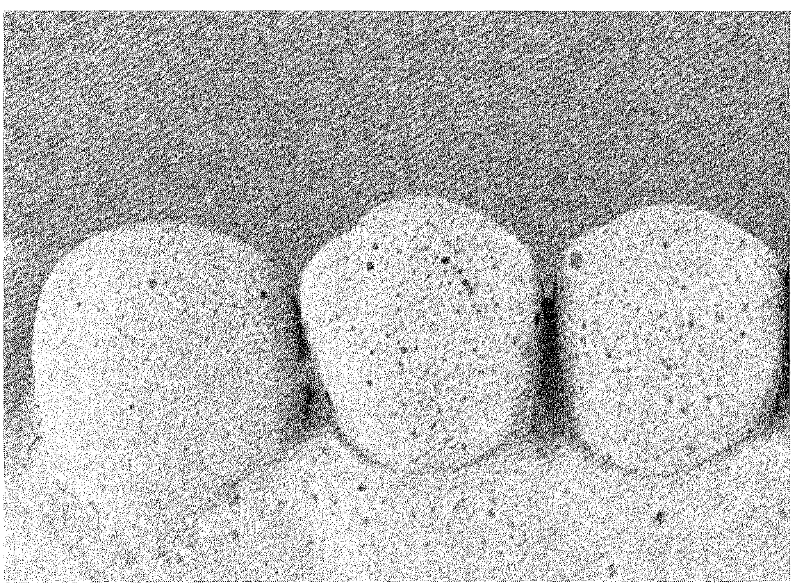

FIG 1. *Stone casts with pores*

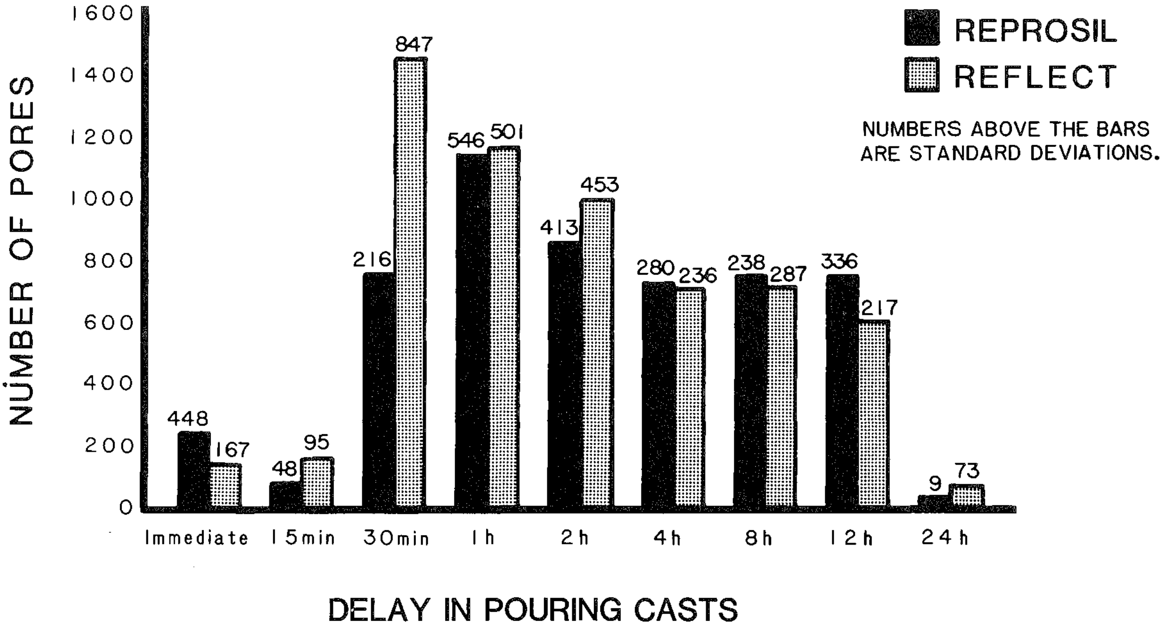

FIG 2. *Histogram displaying the number of pores in casts poured from Reprosil and Reflect after various intervals of delay*

observed for the five casts poured from Reprosil and Reflect at different intervals of time are shown in a histogram in Figure 2.

The casts produced from both materials exhibited surface porosity of varying degrees at all intervals of time. A few casts, however, exhibited no pores at some, but not all, locations. In general, with few variations, a common trend of increasing number of pores for the first few intervals of time and a subsequent pattern of decreasing number of pores were noted on casts from both Reprosil and Reflect. For the initial intervals of time, the fewest pores were observed in a cast poured at 15 minutes for Reprosil and a cast poured immediately for Reflect. The maximum number of pores was noted in casts poured after one hour for Reprosil and after 30 minutes for Reflect. The variation in the number of pores from cast to cast was especially high at the earlier intervals of time, as indicated by relatively large standard deviations shown in Figure 2.

For both impression materials the differences between the number of pores in the casts poured at adjacent intervals of time displayed various levels of significance as shown in the table.

Statistical Significance of Differences in Porosity of Casts Poured at Adjacent Intervals of Time

Intervals of Time	Statistical Significance	
	Reprosil	Reflect
Immediate - 15 min	$P < 0.05$	$P < 0.0001$
15 min - 30 min	$P < 0.005$	NS
30 min - 1 h	NS	NS
1 h - 2 h	NS	NS
2 h - 4 h	NS	NS
4 h - 8 h	NS	NS
8 h - 12 h	NS	NS
12 h - 24 h	$P < 0.0001$	$P < 0.001$

With the exception of the casts poured after 30 minutes, there were no statistically significant differences between the number of pores in casts prepared from the two materials. The difference between the number of pores for casts from Reflect and Reprosil poured after 30 minutes was statistically highly significant ($P < 0.001$). There were no statistically significant differences for various locations or between the hard surface of the tooth and the soft surface of the mucosa.

These data suggest that to obtain minimal porosity the casts should be poured within 15 minutes of making the impression. For Reprosil impressions it may be advisable not to pour the casts immediately. However, the difference between a cast poured immediately and one poured at 15 minutes is not likely to be significant. Also the delay of 15 minutes may allow more elastic recovery of the material resulting in a cast that is dimensionally more accurate.

The decrease in the number of pores between 12 and 24 hours is substantial. The minimum degree of porosity exhibited at 24 hours may have been reached any time after the first 12 hours. And, in such an eventuality, it would be possible to obtain casts virtually free of porosity after that period. However, based on the results obtained here, it appears that pouring the casts within the first 15 minutes or after 24 hours yields the minimum porosity.

Theoretically, any delay in pouring the casts has a potential for introducing inaccuracies due to possible dimensional changes. For vinyl polysiloxane materials, apparently, this effect is negligible due to their excellent dimensional stability. It should be kept in mind, however, that the dimensional stability of the impression material depends to some extent on the conditions of storage. Unpredictable fluctuations in temperature and humidity may lead to dimensional changes, thus causing inaccurate impressions after 24 hours of storage. It would be best, therefore, to pour the cast as soon as possible after taking the impression.

In this experiment, although the simulated teeth and mucosa were of different texture and hardness, they were at the same temperature and humidity. In clinical practice the teeth are likely to be relatively drier than the mucosa. It is not known whether the casts produced from clinical impressions show differences in the extent of porosity on the tooth and mucosal surfaces. In any event such a difference is inconsequential if the casts are poured immediately. Furthermore, at the intervals of time resulting in relatively large degrees of porosity, it is unlikely that casts with substantially fewer pores on the surfaces of the teeth than on the mucosal surfaces could be produced. The porosity on the surface of the tooth is of far greater consequence in restorative dentistry than that on the mucosal surface because the pores might involve the critical cavosurface margins.

The results of this study cannot be directly related in quantitative terms to the clinical situation, mainly due to the differences in temperature, humidity, and texture between the human mouth and a Dentoform model. It is felt, however, that the evolution of hydrogen gas, which is inherent in these impression materials, would not be influenced by the temperature and humidity encountered in the mouth. It is reasonable, therefore, to assume that the results are qualitatively indicative of the trend for the initial increase and a subsequent decrease in the number of pores over increasing intervals of time.

It should be pointed out here that the porosity studied in this investigation was due to the evolution of hydrogen gas from the recently set impression materials. Such porosity differs greatly in size and shape from the voids formed in the stone casts due to poor wetting of the impression materials by the gypsum die materials as has been reported (Lorren, Salter & Fairhust, 1976).

Recently, modified formulations of vinyl polysiloxanes have been made available to the dental practitioners. These materials are said to have minimized the problem of the evolution of hydrogen gas in them by the incorporation of finely divided palladium (Tomioka, Watanabe & Iwata, 1981). Clinical performance of such materials has not yet been reported.

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Effect of Polishing on the Marginal Integrity of High-Copper Amalgams

ROBERT B MAYHEW • LAWRENCE D SCHMELTZER
WAYNE P PIERSON

Summary

Three class 2 amalgam restorations, using FS Dispersalloy for all, were placed in each of 13 patients to clinically evaluate the marginal integrity of unpolished and polished high-copper amalgam restorations using wet and dry polishing techniques. Two of each three restorations were polished, one with a slurry of pumice and Amalgloss and the other with three grits of Shofu finishing points under continuous air spray. The third was left unpolished.

At three years, results suggest that polishing high-copper amalgams with either wet or dry materials may have little effect on the marginal integrity of the restorations.

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Requests for reprints to Dr Mayhew

INTRODUCTION

Through the years, polishing has been recognized as an important step in the process of completing an amalgam restoration. Numerous reasons for polishing conventional alloys have been reported (Creaven, Dennison & Charbeneau, 1980; Gilmore & Lund, 1973; Goldfogel, Smith & Bomberg, 1976; Wing, 1965), but the need for polishing the new generation high-copper alloys has not been clearly established.

Many different polishing techniques have been advocated using both wet (pumice/tin oxide) and dry (rubber polishing cups and points) materials (Charbeneau, 1965; Feller & Eames, 1978; Goldfogel & others, 1976; Mosteller, 1950). Although many different techniques have been advocated, certain precautions relating to heat generation have been suggested (Creaven & others, 1980; Goldfogel & others, 1976; Mosteller, 1950). In vitro studies have demonstrated that polishing with dry techniques and nonpowdered abrasives can generate undesirable temperatures (Feller & Eames, 1978; Grajower, Kaufman & Rajstein, 1974; Swedlow & others, 1972) which may lead to mercury release, corrosion, and loss of marginal integrity of conventional alloys (Cunningham, 1977; Dahi & others, 1978; Swedlow & others, 1972).

However, the new generation high-copper alloys have been shown to have greater marginal integrity, partly attributable to their low content of such phases as gamma-2 (Forsten & Kallio, 1976; Mahler, Terkla & Eysden, 1973; Mahler & others, 1970). Yet, there are no clinical studies on the effects of polishing high-copper alloys. Accordingly, the purpose of this study was to clinically evaluate the marginal integrity of unpolished and polished high-copper amalgam restorations using wet and dry polishing techniques.

MATERIALS AND METHODS

The original sample size of patients was 22, with 13 available for evaluation at the end of three years. Three class 2 amalgam restorations were placed in each patient. Tooth selection was based on the need to treat unrestored carious lesions or those with defective amalgams. One operator placed all restorations under rubber dam, and preparations were done according to the technique prescribed by Gilmore and others (1977). Bases were placed in deep cavities and two coats of Copalite (Harry J Bosworth Co, Skokie, IL 60076, USA) cavity varnish were applied to all preparations. Fastset Dispersalloy (Johnson & Johnson Dental Products Co, East Windsor, NJ 08520, USA) was used for all restorations. Mixes were triturated for 10 seconds at the M-2 setting on a Vari-Mix II-M triturator (L D Caulk Co, Milford, DE 19963, USA). Amalgam condensation was done by hand, and preparations were overfilled and carved back to the margins with small discoid-cleoid and Hollenback ½-3 carvers. No polishing or finishing was done at this appointment.

Patients were recalled within one to 14 days after amalgam placement. Both the selection of the teeth and the polishing technique were determined by a toss of a die. One of the three restorations was polished beginning with 12-fluted carbide finishing burs followed by a mixture of water and flour of pumice in a rubber cup. Interproximal areas were polished with the pumice slurry and dental tape. The final sheen was accomplished with a mixture of Amalgloss (L D Caulk Co) and alcohol on a soft bristle brush. The second of the three restorations was polished starting again with 12-fluted carbide finishing burs followed by dry Shofu (Shofu Dental Corp, Menlo Park, CA 94025, USA) brownie points and cups, greenie points and cups, and super-greenie points and cups under continuous air spray. The third of the three restorations remained unpolished as a control. One operator polished all restorations using slow speed and light intermittent pressure.

At the end of the polishing appointment, baseline black-and-white photographs were taken of each restoration using a Minolta (Minolta Camera Co, Ramsey, NJ 07446, USA) bellows intraoral camera. Camera settings remained constant to produce a magnification of X1.0. Panatomic-X (Eastman Kodak Co, Rochester, NY 14650, USA) black-and-white film was used for better contrast. Photographs were enlarged to X4.3, printed on Kodak paper (Eastman Kodak Co) and cropped to show only the restored tooth. Patients were recalled at six months and three years postoperatively for photographs. These photographs were examined and evaluated by three experienced dentists. Each photograph was initially placed into one of six categories according to the severity of marginal breakdown, category one having the least marginal breakdown. Then these same examiners rank-ordered the photographs as described by Osborne and others (1976). The best was ranked one and so on.

Inter-rater agreement was evaluated using Kendall's Coefficient of Concordance. The effects of polishing, and polishing technique, were measured with a Kruskal-Wallis one-way analysis of variance for nonparametric data.

RESULTS

Of the 22 patients initially involved in this study, 20 were available for evaluation at six months and 13 at three years (Table 1).

Table 1. Number of Patients Evaluated at Each Time Period

Method	Baseline	Six Months	Three Years
Control	22	20	13
Pumice/Tin oxide	22	20	13
Shofu points	22	20	13

The inter-evaluator agreement as measured by Kendall's Coefficient of Concordance was 0.76 at baseline, 0.85 at six months, and 0.74 at three years. Generally a value of 0.70 to 0.80 and above is considered good concurrence between examiners. The Kruskal-Wallis test, which compares rank-ordered data, showed that there was only one instance in which a statistically significant difference was found in the rankings and that was at six months and by only one evaluator (Table 2). The other eight rankings yielded no significant differences between the treatment methods. Figures 1 through 9 show representative examples of each treatment group at baseline, six months, and three years.

DISCUSSION

This study compared the marginal breakdown of unpolished Dispersalloy amalgam restorations to Dispersalloy restorations polished with wet and dry techniques. At six months the data suggested better margins were found on restorations polished dry with Shofu points and cups with next best margins found on restorations polished wet with pumice and tin oxide. The control (unpolished) restorations were ranked at the low end of the scale. One evaluator ranked the dry technique as being significantly better than either the wet technique or the control. However, at three years all differences between the treatments had disappeared.

Osborne, Schlissel and Gale (1981) reported a strong relationship (r = 0.93) between six-month and three-year evaluations of marginal breakdown with 12 different alloys in a clinical study of 750 restorations. Their report suggested that the criterion of marginal integrity at six months could be a fair predictor of performance at three years. In this study the appearance of the margins at three years more closely

Table 2. Marginal Breakdown and Polishing Techniques (Kruskal-Wallis Analysis of Variance)

Method	Baseline Rank Sums			Six-Month Rank Sums			Three-Year Rank Sums		
	Evaluator			Evaluator			Evaluator		
	I	II	III	I	II	III	I	II	III
Control	622	575	599	772	681	760	243	193	228
Pumice/Tin oxide	650	672	644	615	655	571	245	267	254
Shofu points and cups	557	583	587	443	494	499	215	243	221
Kruskal-Wallis test statistic	0.74	0.95	0.29	8.88*	3.36	5.95	0.28	1.29	0.06

*$P < .05$

FIG 1. *Baseline control*

FIG 2. *Control – six months*

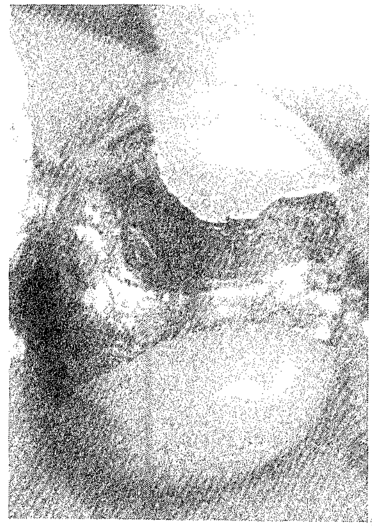

FIG 3. *Control – three years*

FIG 4. *Baseline pumice/tin oxide*

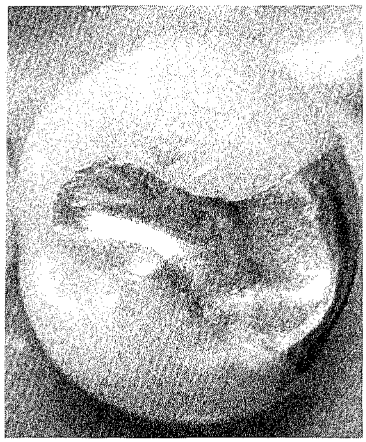

FIG 5. *Pumice/tin oxide – six months*

FIG 6. *Pumice/tin oxide – three years*

FIG 7. *Baseline Shofu treatment*

FIG 8. *Shofu cup/points – six months*

FIG 9. *Shofu cup/points – three years*

paralleled the rankings at baseline than those at six months, yet there was a similarity between six-month and three-year rankings. However, in contrast to the Osborne study, the major purpose of this investigation was to compare the marginal integrity of differently treated restorations at specific time intervals versus comparing performance over time.

In vitro studies have demonstrated that polishing with dry techniques and nonpowdered abrasives can generate undesirable temperatures which may lead to mercury release, corrosion, and loss of marginal integrity of conventional alloys (Aplin, Sorenson & Cantwell, 1967; Christensen & Dilts, 1968; Mitchell, Dickson & Schoonover, 1955). Yet, a study by Eames in 1981 has shown that the Shofu amalgam polishing technique produced a polished surface well within acceptable limits of slight temperature elevation of 4 to 8 degrees, and that these polishing instruments can provide a fine amalgam finish. Heat generation was not a parameter directly evaluated in this study, but if it is a clinically significant factor, then a greater amount of marginal breakdown should have been observed among the polished restorations in comparison to the controls.

The analysis of the data and the evaluation technique used in this study merit some discussion since they are modifications of other reported protocols. Osborne and others (1976) evaluated five techniques for measuring the marginal breakdown of three-year-old amalgam restorations and reported that the rank-ordering technique, in which evaluators ranked clinical photographs of restorations from best to worst, proved to be the most useful. Extremely high correlations among five paired raters were reported (Spearman's rho: 0.99 to 0.98). Quite acceptable results have been reported here using Kendall's Coefficient of Concordance (0.76, baseline; 0.85, six months; 0.74, three years), a statistical test which is specifically designed for evaluating three or more evaluators' rankings (Gibbons, 1976). Also, the Kruskal-Wallis analysis (which is based on ranked data) provided an excellent nonparametric comparison of each polishing technique. This rank-ordering technique avoids the disadvantages of transforming data, as with the ridit analysis, and is probably more discriminating than a clinical ranking method (Osborne & others, 1976).

Theoretically one would expect that the margins of a restoration that had been finished at a subsequent appointment would show less breakdown than unfinished and unpolished margins at a three-year point. However, in this study careful attention was directed toward placing each restoration under ideal conditions. That is, special attention was given to the use of rubber dam in a well-designed preparation using adequate condensation with a highly rated amalgam restorative material. It may, therefore, be possible under these conditions that a careful carving of the amalgam at the initial restorative appointment may go a long way toward providing an adequately finished margin that is not greatly improved with finishing and polishing at a subsequent appointment. That is, the operator variable may be clinically significant. An experienced, motivated, and meticulous operator, such as the dentist who placed the restorations in this study, may be able to produce margins at the initial appointment that are equivalent to those prepared by others after a finishing and polishing appointment. This remains speculation but could be objectively evaluated in another study in which the experience of the operator was a major variable.

CONCLUSIONS

1. At three years in vivo, high-copper amalgam restorations, either left unpolished or polished with pumice/tin oxide or Shofu cups and points, exhibited similar marginal integrity.

2. Nonpowdered abrasives, when properly used, do not appear to deleteriously affect the marginal integrity of high-copper amalgam restorations.

3. Finishing and polishing high-copper amalgam restorations may not be efficacious when judged only on the parameter of marginal integrity at three years.

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Interfacial Space, Marginal Leakage, and Enamel Cracks around Composite Resins

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Summary

Changes in interfacial space, marginal leakage, and enamel cracks, produced by changes in temperature, were investigated in this study to determine the effects of temperature upon conventional composite resins as compared with microfilled resin. Effects were most pronounced in restorations of microfilled resin; marginal leakage correlated with the presence and size of interfacial spaces; and enamel cracks were found more often in relation to the microfilled resins.

INTRODUCTION

Composite resins, the tooth-colored direct filling materials most widely used, represent an improvement over unfilled resins but still have shortcomings. These include polymerization contraction and a relatively high coefficient of thermal expansion, which result in poor adaptation of the resin to tooth structure and subsequent leakage at the margins (Ortiz & others, 1979), especially when the restoration is placed under thermal stress (Asmussen, 1974). Etching the enamel and the use of a bonding agent can improve the seal of resin to tooth and the strength of that bond, but fractures of enamel may result. These fractures, which appear as cracks near the margin and parallel to it, are thought to arise from contraction of the composite bonded strongly to the enamel (Jørgensen, Asmussen & Shimokobe, 1975; Øilo & Jørgensen, 1977). Adaptation to dentin can also be improved by etching with acid (Satoh & others, 1979), though this practice has been questioned because of possible damage to the pulp (Retief, Austin & Fatti, 1974).

There are now over 60 composite resins on the market, including the new microfilled resins (Jacobsen, 1981). Their coefficients of thermal expansion vary from about 20 x 10^{-6} °C^{-1} to 100 x 10^{-6} °C^{-1}, with the microfilled resins occupying the higher end of the range (Masuhara, 1981). Marginal percolation, a phenomenon first described in 1952, was thought to be the result of the large difference between the coefficients of thermal expansion of tooth structure and the acrylic materials used for direct filling (Nelsen, Wolcott & Paffenbarger, 1952). Since some of the microfilled resins have coefficients of thermal expansion in the same range as the unfilled acrylic resins, one would expect that the microfilled resins would be more affected by changes in temperature than conventional composite resins.

The purpose of this study was to evaluate the effects of changes in temperature on the size of the space between the restorative material and tooth structure in etched cavities. Also studied was the relationship of thermal changes to marginal leakage and fracture of enamel. A conventional composite (Clearfil, Kuraray Co, Kurashiki, Japan) with a relatively low coefficient of thermal expansion (31.1 x 10^{-6} °C^{-1}) was compared with a microfilled composite (Isopast, Vivadent Schaan, Lichtenstein) having a relatively high coefficient of thermal expansion (80.3 x 10^{-6} °C^{-1}) (Masuhara, 1981).

MATERIALS AND METHODS

Sixteen noncarious human central incisors, freshly extracted, were used for this study. The enamel was examined in a stereo microscope at a magnification of X40 and any teeth with cracks or hairline fractures in any direction were discarded. The teeth were stored in water after extraction and between procedures to prevent dehydration. Class 5 cavities were prepared in the facial surfaces of the teeth with a diamond bur in a high-speed handpiece using water spray as a coolant, and finished with a steel bur in a slow-speed handpiece. Retention points were placed with a ¼ round bur. All cavities were cut by the same operator. The occlusocervical distance was standardized at 6.0 ± 0.1 mm. The cervical margin was established as a butt joint in cementum and the enamel margin was beveled at 45°. After preparation, the teeth were randomly divided into two groups of eight teeth each. All cavities (including axial and cervical walls) were etched for one minute with a commercial etchant, rinsed with copious amounts of water, and dried with an air syringe for 15 seconds before the restorations were placed. One group was restored with the conventional composite resin, the other with the microfilled resin. Each resin was mixed and placed according to the manufacturer's directions, including priming of all walls of the cavities with the bonding agent provided. All restorations were finished to proper contour with disks (Soflex, 3M Dental Products, St Paul, MN 55144, USA), then cleaned ultrasonically in water for five minutes to remove any grinding debris.

Next, the teeth were cycled in water baths at 4 °C and 60 °C three minutes in each bath, for a total of 100 cycles. Then the facial surfaces of the teeth were replicated by a previously described technique (Takagi, Nishimura & Fukuda, 1978). Impressions of the facial surfaces of all teeth were made at two different temperatures, 4 °C and 60 °C. The teeth were maintained at the given temperature in a moist petri dish for 15 minutes before the impression was made; the impression material (Exaflex, GC Co, Tokyo, Japan) had been brought to the same temperature beforehand. The impressions were then poured in epoxy resin (GY 252, Ciba-Geigy Co, Basel, Switzerland).

The teeth were next coated with nail varnish, leaving only the restoration and its margins exposed. They were then stored overnight at room temperature in a freshly prepared 0.025% aqueous solution of methyl violet. The following day the teeth were rinsed and sectioned faciolingually using a diamond wheel cooled with water. One section of each tooth was polished with fine-grit sandpaper followed

Table 1. Changes in Interfacial Space

		Changes in Width of Space (μm)				
		Facial Casts		Casts of Sections		
Group	Tooth Number	Cervical Margin	Occlusal Margin	Cervical Wall	Occlusal Bevel	Axial Wall
	1	X	X	+ 3.0	X	– 3.8
	2	+ 3.0	X	0.0	X	– 2.7
	3	+ 0.7	X	– 2.2	X	– 0.7
	4	– 3.0	X	0.0	X	X
Conventional composite	5	+ 0.7	X	+ 5.2	X	0.0
	6	+ 1.5	X	+ 1.5	X	– 4.8
	7	+ 5.7	X	X	X	X
	8	– 1.5	X	– 3.0	X	X
	9	+ 1.8	+ 4.5	+ 4.3	0.0	– 7.2
	10	– 2.3	+ 1.5	+ 3.0	X	+ 3.0
	11	+11.5	X	0.0	+ 6.0	–10.5
	12	0.0	X	+ 0.7	X	– 3.0
Microfilled composite	13	– 0.4	+ 4.5	0.0	X	+ 2.2
	14	+ 5.5	+12.7	+ 3.2	+ 2.3	– 5.3
	15	– 1.9	+ 6.0	+ 4.5	+ 0.6	– 6.0
	16	+12.0	X	– 2.2	X	– 2.2

\+ Space larger in cold cast
– Space larger in hot cast
X Closed margin, both hot and cold cast

by a fine polishing stone, always under lubrication with water. Scores for the penetration of the dye were obtained by means of a stereo microscope at a magnification of X40. The system of scoring is shown in Figure 1.

The teeth were again cleaned ultrasonically, and the same procedure for impressions was repeated to obtain casts of the faciolingual sections at 4 °C and 60 °C. Thus a total of four casts were made of each tooth — two facial casts and two casts of sections. These casts were coated with gold ions in a coating machine and examined in a scanning electron microscope (JXA-50A, JEOL Co, Tokyo, Japan).

During examination of the casts of the sections, an effort was made to observe the same area in the hot and cold specimens. The measurements were taken near, but not necessarily at, the margin. The area of greatest opening was photographed during the examination of the axial wall in the casts of the sections and of the margins in the facial casts. In the facial casts, it was not always possible to observe exactly the same area in both hot and cold specimens; in each case, however, the entire occlusal and cervical margins were examined. Any cracks in tooth structure were noted. Results are based on the evaluation of 213 photographs, most of them taken at a magnification of X1000, shown here at X480.

RESULTS

Width of Interfacial Spaces

Changes in the width of the space between the restorative material and the tooth are expressed as the difference between the measurements from the hot and cold casts (Table 1). A positive number indicates that the space is larger in the cold cast; a negative number indicates the opposite result, and an X indicates a closed margin in both hot and cold specimens. Measurements of spaces as observed in the casts of the sections were averaged within

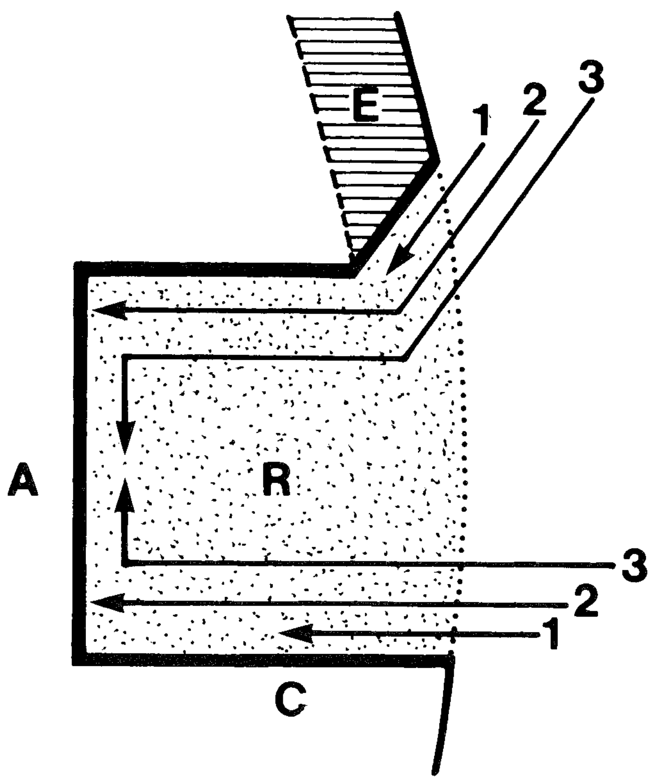

FIG 1. *The scoring system for penetration of dye (*A *- axial wall;* C *- cervical wall;* R *- resin;* E*-enamel):*

1 = *partial penetration along occlusal or cervical wall;*

2 = *complete penetration along occlusal or cervical wall;*

3 = *complete penetration along occlusal or cervical wall and along the axial wall.*

Table 2. Width of Space between Restoration and Tooth

Group	Facial Casts: Cervical Margin Mean	Facial Casts: Cervical Margin SD	Facial Casts: Occlusal Margin Mean	Facial Casts: Occlusal Margin SD	Casts of Sections: Cervical Wall Mean	Casts of Sections: Cervical Wall SD	Casts of Sections: Occlusal Bevel Mean	Casts of Sections: Occlusal Bevel SD	Casts of Sections: Axial Wall Mean	Casts of Sections: Axial Wall SD
	Width of Space (μm)									
Conventional composite:										
Cold	3.6	2.4	0.0	0.0	3.1	1.9	0.0	0.0	2.1	2.4
Hot	2.7	2.9	0.0	0.0	2.5	2.1	0.0	0.0	3.6	3.6
Microfilled composite:										
Cold	9.6	2.8	3.7	4.1	7.7	2.6	4.0	6.2	19.3	5.7
Hot	6.4	3.5	0.0	0.0	6.0	3.4	2.9	4.3	23.0	7.3

each group to show the general trend; these averages are presented in Table 2.

With some exceptions, the spaces were larger in the cold state. The changes were largest in the restorations of microfilled resin, which is consistent with the trend of the coefficients of thermal expansion. A notable and consistent exception is the space at the axial wall in restorations of both types of resin, a space generally increasing in the hot casts. Apparently, the resin expanded facially because it had no other place to go under thermal stress; consequently, there was a peeling of the resin from the axial wall and bowing out of the cavity. This effect is most pronounced in restorations of microfilled resin where the space at the axial wall is the largest of both groups (Fig 2).

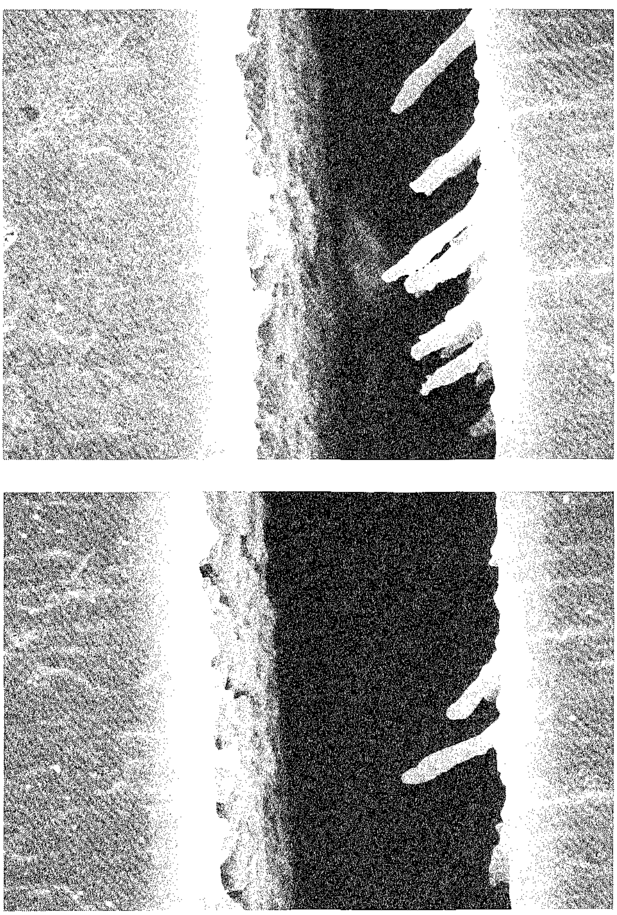

FIG 2. *Axial wall space in microfilled composite restoration; X480 (original magnification X1000).*
Top: *Cold model*
Bottom: *Hot model*

The two materials also exhibited different patterns of adaptation or adhesion to the cavity walls. The only bond not observed to fail was that of conventional resin to enamel (Fig 3). The bonds to enamel of two of eight microfilled resins appeared closed from all views.

An interesting phenomenon observed in several places in the space at the axial wall of restorations of microfilled resin was that when the resin peeled away from the axial wall, tags of resin appeared to be pulled out of dentinal tubules (see Fig 2). The same site is shown in both photographs, but not all the tags of resin were reproduced in the second impression. The cementum margin appeared closed from all views in one of the conventional resins. Of the microfilled resins, the cementum margin showed the greatest opening and the largest difference between hot and cold casts (Fig 4).

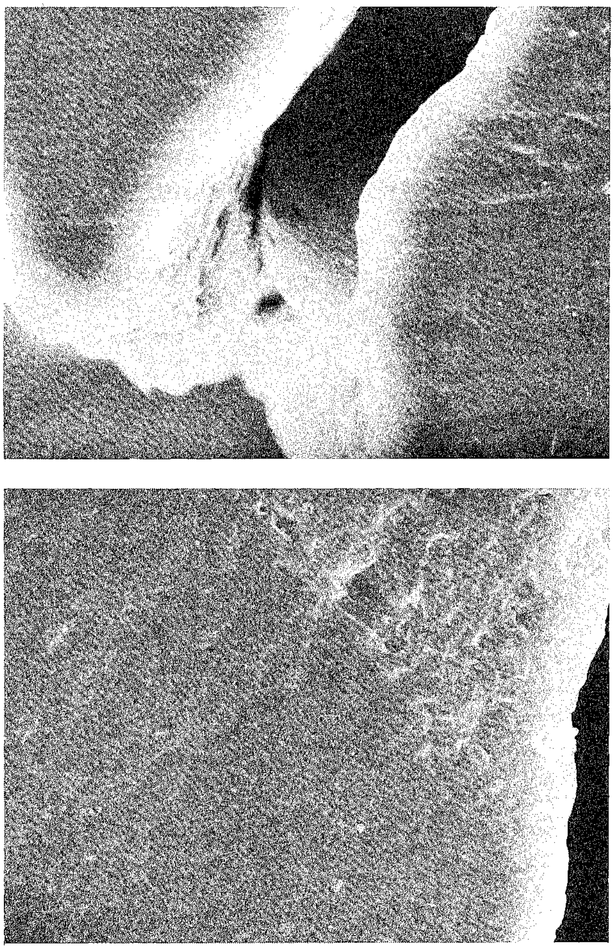

FIG 3. *Comparison of adaptation of the two restorative materials to enamel; X480 (original magnification X1000).*
Top: *Conventional composite*
Bottom: *Microfilled composite*

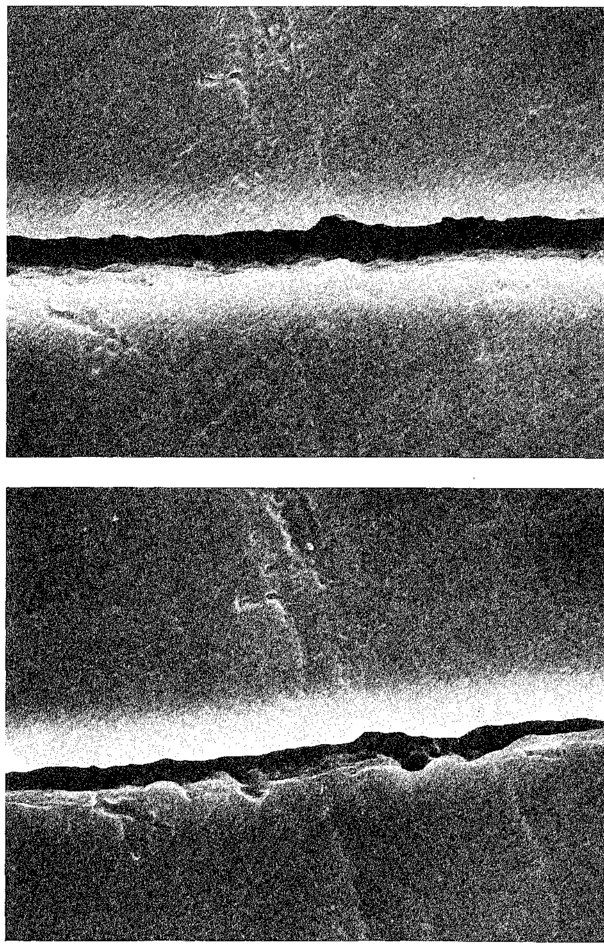

FIG 4. *Gingival wall space in Isopast restoration; X480 (original X1000).*
Top: *Cold model*
Bottom: *Hot model*

Marginal Leakage

The scores for leakage, presented in Table 3, are in general agreement with the observations of the resin restorations in the scanning electron microscope (SEM). The interface of conventional resin and enamel was most resistant to leakage. The microfilled resins show the most leakage, especially at the cementum margin.

Cracking of Enamel

Most of the cracks in the enamel were found in the teeth with the microfilled resins; there being five teeth with microfilled resin displaying cracks and only one crack in a tooth with a conventional resin. Figure 5 shows a crack that did not reach the surface in a cast of a section,

Table 3. Dye Penetration Scores

Score	Conventional Composite		Microfilled Composite	
	Occlusal	Cervical	Occlusal	Cervical
0	6	0	2	0
1	2	8	2	0
2	0	0	1	3
3	0	0	3	5

Numbers of teeth in each scoring category are given.

and Figure 6 shows a crack on the facial surface. Both of these restorations are of microfilled resin.

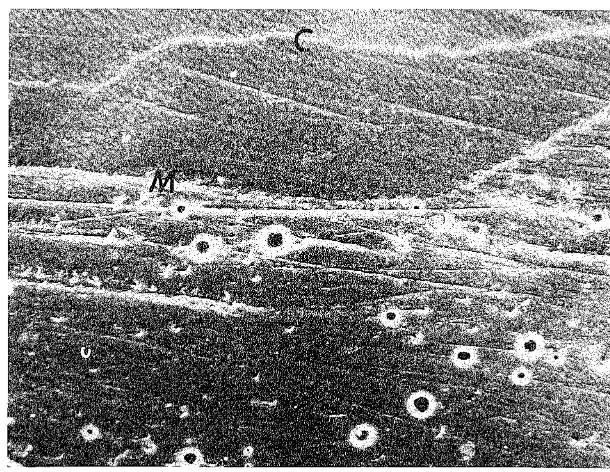

FIG 6. *Enamel crack on the facial surface* (C - *crack;* M - *margin); X48 (original magnification X100).*

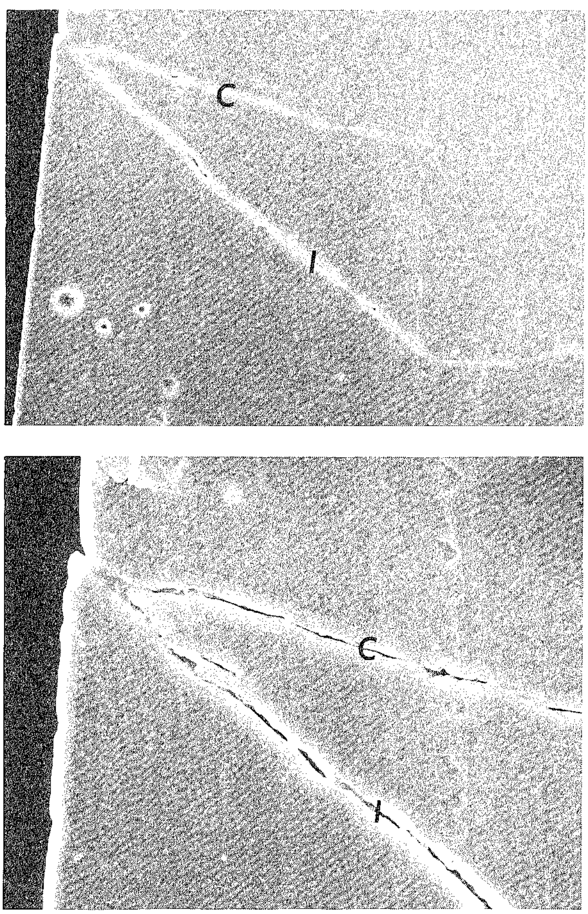

FIG 5. *Enamel crack in a section model* (C - *crack;* I -*interface).*
Top: *X48 (original magnification X100)*
Bottom: *X240 (original magnification X500)*

DISCUSSION

Width of Interfacial Spaces

The results of this study show that thermal changes can produce considerable movement of restorative material. These changes and the resulting spaces between restoration and tooth are largest around the microfilled resin, which has the highest coefficient of thermal expansion. The space generally increased in the cold state at the occlusal and cervical margins, which is in agreement with recent observations (Asmussen, 1974). Our data, however, show some inconsistencies and in a few instances do not conform to the expected results.

The presence and size of the space is, most likely, related to several factors: initial adaptation of restorative material to wall of cavity; subsequent dimensional changes of the material due to shrinkage of polymerization, thermal contraction, absorption of water, or mechanical stress; dimensional changes in tooth structure due to thermal changes or mechanical stress; strength of the bond between restorative material and tooth structure; and the ability of the bond to resist strain. These are in turn affected by other factors, which can be controlled by the operator: size and design of cavity; method of instrumentation; chemical and physical treatment of walls of cavities, such as use of cavity cleaners, etching, drying, and so forth; and choice of restorative materials, including varnish, promoters of adhesion, and bonding agents.

This study was limited to examining the effect of two of these factors: thermal changes and choice of restorative material. Other factors are recognized to affect this study's results, since they cannot be held completely constant. The samples in our study were observed after 100 cycles of temperature changes. The composite resin was still bonded to tooth structure in some places and was apparently undergoing bowing and shifting as well as thermal expansion and contraction. This may account for the variation we observed in space changes and an occasional opposite result. For example, the curvature of the axial wall could influence the peeling of the resin from the axial wall in the hot state. As the resin expands, it meets resistance from the occlusal and cervical walls and moves in another direction. The axial walls of the cavities in this study were convex and approximately parallel to the facial surface of the teeth. This allowed the resin to expand facially, increasing the space at the axial wall in the hot state. We might expect that a concave axial wall would cause the opposite result — smaller space at the axial wall in the hot state.

Etching of enamel for restorations of composite resin is now a standard clinical procedure. It improves the strength of the bond and increases resistance to marginal leakage (Ortiz & others, 1979) and secondary caries (Tanizaki & others, 1981) by eliminating the space between the resin and enamel. The bond can be further improved by beveling the enamel margin, thereby reducing leakage and decreasing the frequency of fractures in enamel (Øilo & Jørgensen, 1977).

Etching of dentin has been questioned because of possible damage to the pulp by penetration of phosphoric acid through dentin (Retief & others, 1974; Bowen, 1978). However, some studies indicate that phosphoric acid cannot penetrate dentin (Houzar, Sindelka & Feit, 1963; Johnson & others, 1970; Lee & others, 1973). The effect of etching dentin is to remove the smear layer produced during preparation of the cavity and open the dentinal tubules by dissolving plugs of debris and increasing their diameter to a depth of 10-20 μm (Shortall, 1981; Brännström & Johnson, 1974). The permeability of dentin can thus be increased 32-fold (Pashley, Michelich & Kehl, 1981; Reeder & others, 1978), making subsequent penetration of bacteria and irritants much easier (Vojinović, Nyborg & Brännström, 1973). However, if etched dentin can be sealed to eliminate marginal leakage, no pulpal irritation is found (Brännström & Nordenvall, 1978). Another study concludes that composite resins and etching with acid are not irritating, but that bacterial penetration from marginal leakage is the main cause of damage to the pulp (Brännström & Vojinović, 1976).

Laboratory tests have shown that etching and use of a bonding agent can achieve penetration of resin into dentinal tubules and formation of tags, resulting in higher strength of bond (Satoh & others, 1979). Some manufacturers claim that their bonding agent is particularly formulated to adhere to etched dentin, and one study cites a morphologic difference between resin tags of different bonding agents to support this claim (Suizu, 1981). Formation of tags in vivo has also been demonstrated (Nordenvall & Brännström, 1980).

This study was designed to provide optimal conditions for the composite resin materials; the enamel margins were beveled and all walls of cavities were etched. This proved to be very effective in eliminating the space between the conventional composite and beveled enamel; this bond was not disrupted in any of the restorations. The bond of microfilled resin to enamel was disrupted in six of eight teeth, presumably because of the contraction of polymerization and thermal stress.

The cervical wall proved to be the weakest point of restorations of both types of resins, especially the microfilled resin. A relatively large space and larger changes were found here. The bond of resin to dentin is much weaker than that of resin to enamel, and during any dimensional changes the cervical interface should be disrupted first.

The effects described in this study might be less pronounced in a clinical situation because composite resins have a relatively low thermal conductivity and changes in temperature in the mouth might be of shorter duration. Nevertheless, under the conditions of this study, clear differences were observed between the two materials.

The main advantage of microfilled resins is their smoothness; however, the inferior physical properties may result in poorer marginal adaptation, especially when the cervical margin is extended into the cementum. This is consistent with a recent clinical observation that microfilled resins exhibit inferior marginal adaptation when compared with conventional composite resins (Ameye, Lambrechts & Vanherle, 1981).

Marginal Leakage

The scores of leakage are in general agreement with the sizes of the spaces. The interface of the conventional composite and enamel was most resistant to leakage and the interface of the microfilled resin and the cervical wall showed the greatest leakage. Surprisingly little leakage was found at the cervical wall of the restorations of conventional resin, where a space of moderate size was observed. Possibly some sealing of the etched dentin was achieved by its bonding agent, which is claimed to be formulated to achieve adhesion to dentin. There may be a different mode of failure between this resin and dentin. In the restorations of microfilled resin, tags of resin were pulled out of the dentinal tubules in several places, but this was not observed with the conventional resins.

Apparently, leakage also depends on factors other than presence and size of space. For example, scores for leakage can vary considerably with use of different tracers in the same restorations (Going, Massler & Dute, 1960). The leakage at the interface should be influenced by the characteristics of the surface of the tooth, the surface of the restoration, and any interaction of a particular tracer with these. Other tests for leakage, such as irritation of the pulp from penetration of bacteria (Brännström & Nordenvall, 1978) and resistance to secondary decay (Tanizaki & others, 1981) are more clinically relevant.

Cracking of Enamel

The presence of cracks followed the expected pattern, with the greatest number appearing in the teeth restored with microfilled resin. These cracks, described in three previous studies (Asmussen, 1974; Jørgensen & others, 1975; Øilo & Jørgensen, 1977), are thought to arise when the resin contracts during polymerization or cooling and exerts a pulling force on the surrounding enamel. The adhesive strength between the resin and enamel must exceed the cohesive strength of the enamel for this to occur. It is interesting to note that of the six teeth from the group of microfilled resins that showed cracks, only one had an interface of enamel and resin that appeared closed in both sectional and facial views. The other five restorations were disrupted at the interface as well as within the enamel.

CONCLUSION

The effects of temperature were most pronounced in restorations of microfilled resin, this material having a higher coefficient of thermal expansion than the conventional composite resins.

The space at the occlusal and cervical walls generally increased in the cold state, indicating shrinkage of the restorative material. The space at the axial wall increased in the hot state, indicating expansion of the material and movement in the facial direction.

The marginal leakage correlated roughly with the presence and size of the interfacial spaces.

Enamel cracks were found more often in relation to the microfilled resins and are thought to be related to the greater contraction during polymerization and higher coefficient of thermal expansion.

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DENTAL PRACTICE

Evaluation of Four Substitutes for Asbestos in Lining Casting Rings

WILLIAM A BRANTLEY • JACK C LIU
WILLIAM L KOS • GERALD J ZIEBERT

Summary

When Ney-Liner, R Liner, Kaoliner, and Ring Liner were compared with asbestos for their effect on the accuracy of castings made of Midas, Cameo, and Neydium-NP, it was found that asbestos was associated with the most accurate castings for Midas and Cameo but did not differ from the substitute liners when Neydium-NP was used. In most cases, the differences among the substitute liners were not statistically significant.

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INTRODUCTION

Although asbestos has been for many years the material of choice for lining casting rings, numerous reports on hazards to health from asbestos have recently led manufacturers to market substitute materials for liners. One type of substitute is made from a refractory ceramic-silicate material. These liners will withstand the temperatures for burning out the pattern and can be compressed to allow for expansion of the mold. However, the ceramic material does not absorb water readily, and may provide less than the desired expansion of the investment unless special efforts are made to promote absorption of water. The second type of substitute liner is made of cellulose. This material absorbs water readily and is compressible, so the investment can expand, but the cellulose is flammable and an open space exists after burnout. The resulting loss of support may lead to cracking of the investment, particularly gypsum-bonded investments.

Full crowns cast from type IV gold alloy with the use of liners of ceramic material have been found to be as accurate as similar castings made with the use of liners of asbestos (Steinbock & Asgar, 1978), and no difference was found in the casting accuracy for a substitute for a type III gold alloy when asbestos and two ceramic lining materials were employed (Warfield, Lipson & Priest, 1982). Khatchaturian and Caputo (1982) concluded that asbestos and a ceramic lining material yielded castings of comparable accuracy for a nonprecious alloy. Gil, Moore and Dykema (1982) carefully compared the use of asbestos, ceramic, and cellulose liners in casting type IV gold alloy, and stated that, with an appropriate technique, any of the lining materials could produce consistently acceptable castings.

The purpose of this study was to evaluate how various substitutes for asbestos when used as liners affect the fit of castings made from different alloys in combination with different investments.

MATERIALS AND METHODS

The four lining materials investigated are listed in Table 1. Ney-Liner and R Liner are ceramic materials and are recommended to be used wet. Kaoliner is also a ceramic material, but is recommended to be used dry. Ring Liner is a cellulose, or paper, material and is to be used wet.

Absorption of Water

Initial experiments were performed to determine the capacity of the lining materials to absorb water. The six experimental conditions were as follows:

Table 1. Substitutes for Asbestos in Lining Casting Rings

Product	Type of Material	Manufacturer
Kaoliner	ceramic	Dentsply International York, PA 17404, USA
Ney-Liner	ceramic	J M Ney Company Bloomfield, CT 06002, USA
R Liner	ceramic	Whip-Mix Corporation Louisville, KY 40217, USA
Ring Liner	cellulose	Whip-Mix Corporation Louisville, KY 40217, USA

1. Asbestos — soaked in water

2. Ney-Liner — soaked in water and adapted with finger pressure

3. Ney-Liner — soaked in a 1% aqueous solution of a surfactant (wax pattern cleaner, Jelenko/Pennwalt, Armonk, NY 10504, USA), and adapted with finger pressure

4. R Liner — soaked in a 1% solution of surfactant and adapted with finger pressure

5. R Liner — soaked in a 1% solution of surfactant

6. Ring Liner — soaked in water

Three specimens of each material were used, and a casting ring lined with a single layer of a strip of liner that had been weighed was immersed in the liquid corresponding to one of the six conditions. The times of immersion ranged from 5 to 10 seconds to 5 minutes, depending on the capacity of the material to absorb water. The capacity to absorb water was calculated as grams of absorbed water per gram of liner.

Accuracy of Casting

To compare the fit of castings prepared with asbestos and the other materials, an idealized shape of a full crown with a shoulder finish line was selected, based upon Specification No 2 of the American Dental Association. A stainless steel master die was scaled down (Liu, 1983) to yield a casting of 3 - 4 pennyweight. Two perpendicular grooves were machined off center on the occlusal surface so that the wax pattern and casting could be oriented in only one position on the die. Seventy-five epoxy dies were duplicated from the master die by a commercial firm (Viade Products, Camarillo, CA 93010, USA).

Standard techniques were employed for the preparation and investing of the wax patterns. A single strip of lining material was placed in the casting ring, and the ring then immersed in water or the wetting solution for one minute to wet the liner and thus minimize alteration of the content of water in the mix of investment. The three casting alloys selected were Midas, Cameo (both Jelenko/Pennwalt, Armonk, NY 10504, USA), and Neydium-NP (J M Ney, Bloomfield CT 06002, USA). Midas is a substitute for type III gold, whereas Cameo and Neydium-NP are noble and base metal alloys, respectively, for application of porcelain. Because the alloys differed in composition, melting behavior, and casting shrinkage, three different investments were used: Luster Cast (Sybron/Kerr, Romulus, MI 48174, USA), Biovest (Dentsply, York, PA 17404, USA), and Hi-Temp (Whip-Mix, Louisville, KY 40217, USA). Luster Cast is gypsum-bonded; Biovest and Hi-Temp are phosphate-bonded.

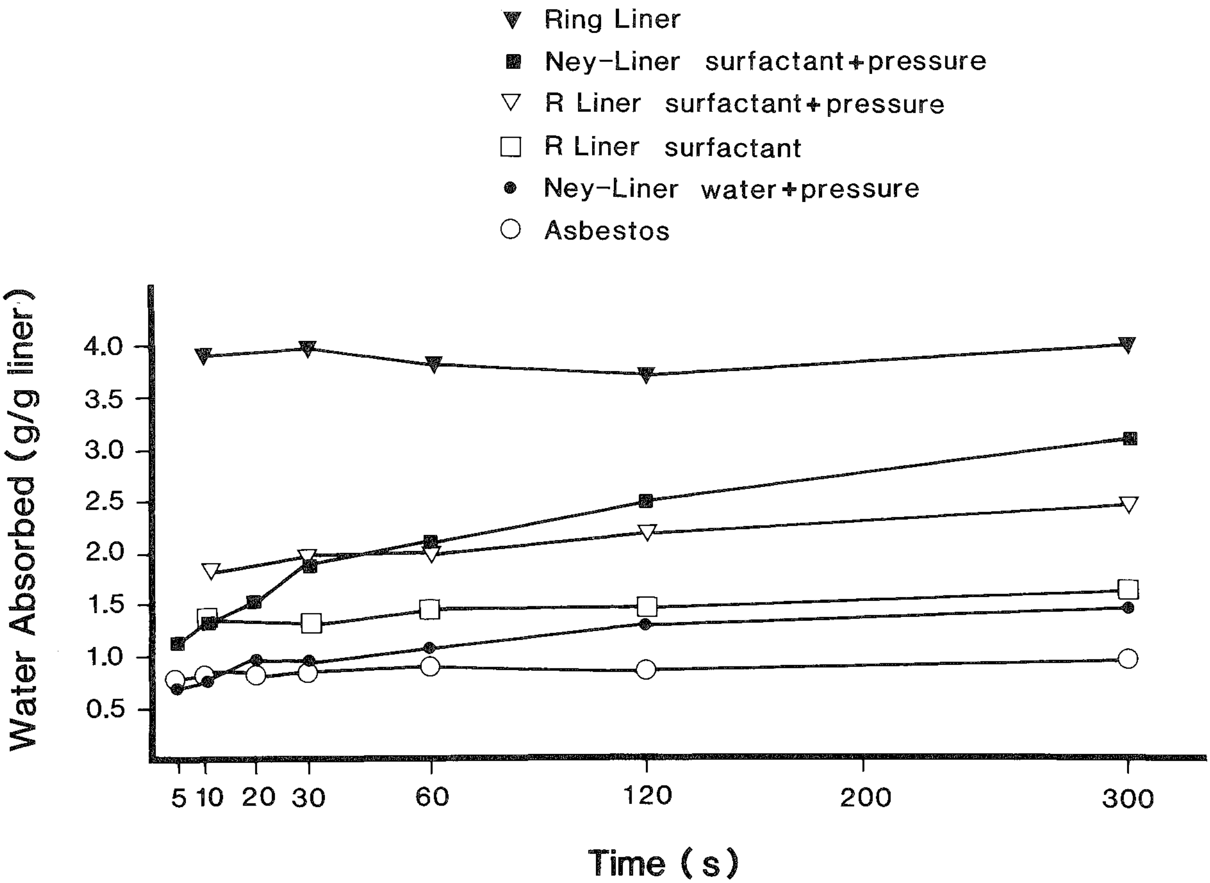
The burnout procedure for each alloy followed the instructions of the manufacturer. Casting was performed with a standard centrifugal casting machine with a broken arm. The ring was cooled on the bench until the sprue button no longer appeared red, and then quenched in water at room temperature. After the investment was scraped away, the casting was cleaned in an ultrasonic cleaner. Castings prepared from Midas also were immersed in a pickling solution (Prevox, Williams Gold, Buffalo, NY 14214, USA) that was heated to the boiling point. Final cleaning was performed by sandblasting the inner surface of the crown with a fine powder of aluminum oxide and an air brush. The sprue was removed from the casting with a separating disc.

A traveling microscope (Gaertner Scientific, Chicago, IL 60614, USA) was used to measure marginal discrepancy, and a special fixture aided in locating four equidistant points of reference on the circumference of the epoxy die. A custom-designed apparatus permitted loading with a weight of 250 g, found to be an optimum amount in preliminary experiments, on the occlusal surface of the crown. The average of the four measurements of marginal discrepancy was reported as the average fit of the casting. There were five replications, or castings, for each type of liner and condition of use. (There were seven different groups of liners, as shown in Table 3 to follow.) Statistical comparisons among the different liners for the same combination of alloy and investment were carried out using the Student-Newman-Keuls test (Weinberg & Cheuk, 1980).

Table 2. Absorption of Water by Liner after Immersion for One Minute and Density of Liner (n = 3)

Liner	Water Absorbed g mean	Water Absorbed / Weight of Liner g/g liner	Weight of Liner g mean	Density of Liner g cm^{-3}
Asbestos	1.58	0.90	1.72	0.085
Kaoliner*	—	—	0.68	0.021
Ney-Liner water + pressure	1.19	1.10	1.07	0.029
Ney-Liner surfactant + pressure	2.35	2.11	1.07	0.029
R Liner surfactant + pressure	1.07	2.01	0.53	0.025
R Liner surfactant	0.79	1.48	0.53	0.025
Ring Liner	2.06	3.82	0.53	0.020

*Recommended for use in dry condition by manufacturer.



Absorption of water by liners

RESULTS AND DISCUSSION

Absorption of Water

The capacity of the lining materials to absorb water is displayed in the figure. The cellulose liner ranked highest, asbestos lowest, and the ceramic liners were intermediate in behavior. The data for absorption of water after immersion for one minute are given in Table 2, along with the density of each brand of liner. The differences in densities for the asbestos and ceramic liners are consistent with photomicrographs published by Priest and Horner (1980), which show a relatively open fibrous structure for the ceramic material and a much denser structure for the asbestos liner.

After 30 seconds the absorption of water for each brand of liner had nearly attained, or was approaching, the final value; consequently, for experimental convenience when preparing the castings, one minute was chosen as the time for wetting the liner. The usefulness of mechanical assistance and a wetting agent to promote absorption of water as recommended by the manufacturers is evident. The data in Table 2 show that the capacity of Ney-Liner and R Liner to absorb water varies considerably with the way they are handled.

Table 3. Marginal Discrepancy of Castings (n = 5)

Liner	Discrepancy μm Midas/Luster Cast mean	SD	Cameo/Biovest mean	SD	Neydium-NP/Hi-Temp mean	SD
Asbestos	36	12	33	14	83	16
Kaoliner	76	16	107	11	98	9
Ney-Liner water + pressure	81	18	86	7	90	14
Ney-Liner surfactant + pressure	77	26	78	28	81	19
R Liner surfactant + pressure	89	11	95	21	87	19
R Liner surfactant	98	16	125	29	62	21
Ring Liner	98	8	137	24	93	9

Accuracy of Casting

Values for marginal discrepancy of the castings are summarized in Table 3. For Midas with Luster Cast, the castings prepared by use of asbestos liners had a smaller marginal discrepancy than those prepared with ceramic and cellulose liners, the difference being statistically significant ($P < 0.01$). No statistically significant differences in accuracy of casting were found among any of the substitute liners.

For Cameo with Biovest, the accuracy of casting achieved with the asbestos liner was also significantly ($P < 0.01$) better than with all the other liners. The castings prepared with Ring Liner displayed the greatest marginal discrepancy but, compared with Kaoliner and R Liner soaked in surfactant, the differences were not significant. Nor were the differences in marginal discrepancy for the castings prepared with Ney-Liner and R Liner soaked in surfactant and adapted with pressure statistically significant. However, the differences in marginal discrepancy were significant for castings prepared with Ney-Liner, compared to Ring Liner and R Liner with surfactant only ($P < 0.01$, except for Ney-Liner with water and pressure compared to R Liner with surfactant where $P < 0.05$).

For Neydium-NP with Hi-Temp, the accuracy of castings prepared with R Liner soaked in surfactant was significantly better ($P < 0.05$) than with the use of Ring Liner and Kaoliner. Otherwise, there were no statistically significant differences among any of the liners, including asbestos, in the accuracy of casting. However, there was a great improvement in casting accuracy for this alloy with Hi-Temp investment, compared with Biovest. In initial experiments with the Biovest, values of marginal discrepancy for Neydium-NP were in excess of 300 μm for all liners.

These results suggest that the principal factor affecting marginal discrepancy is selection of the proper investment to compensate for the shrinkage of the alloy. Casting shrinkage is expected to increase with increases in the melting or casting temperatures, and the casting temperature recommended by the manufacturer for Midas is 1800° F (982 °C), compared to 2400° F (1316 °C) for Cameo and 2550° F (1399 °C) for Neydium-NP.

The cushioning effect from the liner appears to be secondary in the accuracy of casting once a suitable investment has been chosen for an alloy. For example, Table 3 shows there was no significant difference in marginal discrepancy for all three alloys when Ney-Liner and R Liner were soaked in surfactant and adapted to the ring with pressure. While the use of pressure with surfactant for R Liner yielded greater accuracy of casting for Midas and Cameo, compared to the use of surfactant alone, the differences were not statistically significant. The increased water absorption for R Liner when pressure is combined with the surfactant (Table 2) thus appears to have only a small effect on accuracy of casting, under the conditions of this study. Detailed compositional information is proprietary, but the comparable values for density of liner and for water absorption per unit liner weight with surfactant and pressure suggest that the fibrous ceramic-silicates in Ney-Liner and R Liner are of a similar nature. Preliminary tissue culture experiments (Liu, 1983) have indicated no cytotoxic effects for the three ceramic liner materials.

CONCLUSIONS

The cellulose liner, Ring Liner, absorbed more water per unit of weight of liner than did the rest of the materials. For the ceramic Ney-Liner and R Liner, mechanical assistance or the use of a 1% aqueous solution of surfactant, or both, as recommended by the manufacturers, was necessary for the absorption of adequate water.

The asbestos liner appears to be the first choice, based on lowest marginal discrepancy, for the Midas and Cameo alloys. For Neydium-NP, no particular material yielded superior accuracy of casting. When the substitutes for asbestos were compared, little difference was found among them in the accuracy of casting.

The combination of the Neydium-NP alloy with Biovest investment yielded an unacceptable fit of casting. The improved accuracy of casting found with the use of Hi-Temp is attributed to the greater expansion of this investment compared to Biovest.

Acknowledgment

We express our appreciation to David J Steinbock of the Whip-Mix Corporation for helpful discussions on materials for lining casting rings.

(Received 7 December 1984)

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Distinguished Member Award

Those who know Charlie Stebner and me are aware of the close friendship we enjoy, as well as our mutual respect. At times the verbal barbs that have passed between us at these many meetings might indicate otherwise to strangers, but there is too much similarity in our backgrounds and philosophies for our relationship to be other than one of brotherly love and amiable jesting.

Both of our fathers were immigrant coal miners, having left their native countries as very young men to find fortune in that great Utopia across the Atlantic. Our mothers ran rooming-and-boarding houses for miners to help with the dental educational expenses. Unfortunately, Bruno Stebner was killed in a mine accident in Hanna, Wyoming, when Charlie was only five.

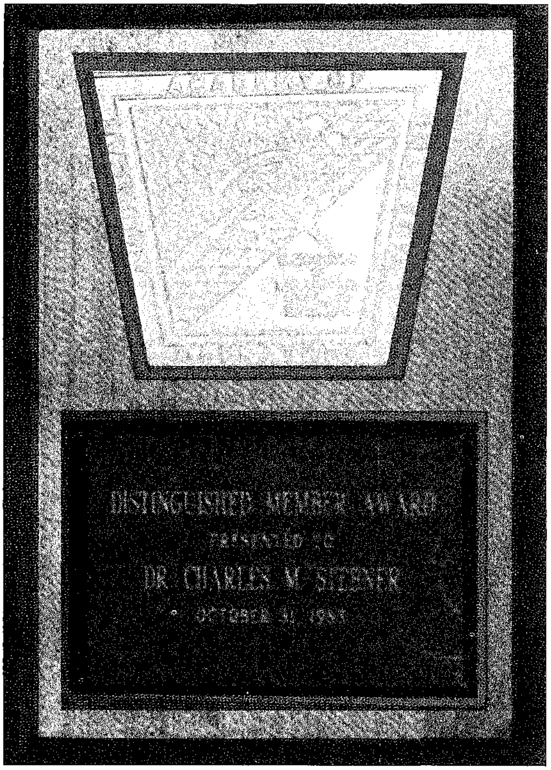
Mary Hughes Stebner, his remarkable 1964 Wyoming "Mother of the Year," having lost both a father and a husband in mine accidents, was determined that her then only remaining child, Charlie, would not be a miner. The fact that she lost her two other children to now curable diseases prompted her to encourage her son to a professional career so that he could serve humanity, which he has done nobly for over 50 years.

Our honoree graduated from Creighton University School of Dentistry and started his practice in Laramie, Wyoming, during 1932, the worst year of the Great Depression. He began his everlasting pursuit of postgraduate education by joining the Woodbury Study Club of Omaha, Nebraska. Here he developed and enhanced his professional skills as well as acquiring a great interest in gold foil and rubber dam.

Charles Stebner

This training prepared him to become a widely known national and international lecturer and teacher in general and operative dentistry.

Few dentists have unselfishly given more of themselves to serve dentistry than has Charlie Stebner. Can you imagine how much office



Plaque presented to Dr Stebner

time he has devoted to his profession when I tell you that he has lectured in 43 of the United States and 7 foreign countries? Remember, this was in days of no or minimal honorariums. He made nearly 200 separate appearances, often demonstrating practical chairside procedures, thereby stimulating the formation of a half a dozen study clubs.

All this dental involvement has not prevented him, during his leisure time, from thoroughly enjoying and participating in his favorite sports of hunting, fishing, and camping. To this day Charlie continues to be an ardent outdoorsman.

He was Laramie's first jogger, beginning some 20 years ago, and still is going strong, almost on a daily basis. He has written and lectured on the subject of physical conditioning and when he speaks to various groups, he says: "By example I hope to encourage others to prevent premature heart attacks." We must admit that at 75 he does set a mighty good example.

During World War II he volunteered for U S Navy duty and was assigned to Farragut, Idaho, as a lieutenant. His service assignments included practicing operative dentistry, oral surgery, teaching corpsmen and junior dental officers, as well as conducting some bacteriologic research. This is not to say Charlie was an ideal dental officer because he set his own rules about quality instead of quantity dentistry along with advocating the constant use of the rubber dam to the frustration of some commanding officers.

When challenged on the time utilized in placing gold foils during clinic time, Charlie would then do these procedures after regular working hours, on Navy families, or anyone who requested same. As much of a rebel as he was, every commanding officer realized his value to the station and would reverse his sea duty orders so Charlie spent all the war years on the waters of Lake Farragut. The first time he put foot aboard a Navy vessel was during a Coronado visit years after the war when I, an Army man, arranged such a visit aboard an aircraft carrier for this frustrated sailor.

Charlie has promoted and continues to participate in many community endeavors. For his dedication he received the Lions Club's Laramie Distinguished Service Award. In dentistry his recognitions are too numerous to mention in their entirety. He has been awarded three fellowships — in the American College of Dentistry, in the International College of Dentistry, and in the American Academy for the Advancement of Science. He is a past-president of the Wyoming Dental Association and in 1983, at Cody, Wyoming, he received the honor of being the first dentist for whom a Wyoming state meeting was dedicated.

In 1983 he was also chosen to participate in a Legends of Dentistry program at Northwestern University, and his alma mater presented him its Alumni Award of Merit in 1967. Most in this room know Charlie Stebner as a past-president of this fine organization but few remember that it was under his term as president-elect and program chairman that this academy began its first operating session at Dade County Clinic in Miami, Florida.

I, for one, am convinced that this one innovation has kept our academy alive these many years because we are the only group willing to appear, even at dental schools, to present chairside operations. For putting this aspect into actual operation this academy should be truly grateful to Charlie Stebner.

It has been said that behind every successful man there is a surprised mother-in-law. I am not sure this applies to Charlie but all of us know that his wonderful wife has been a most understanding, tolerant, and helpful partner, so much so that I have given her the earned title of "Saint Mary."

The Stebners are proud parents of three fine children; sons Ronald and Kenneth and daughter, Marilyn, a Wyoming Junior Miss of a few years ago. Quite a family — a Wyoming Mother of the Year — a Wyoming Junior Miss — and Charlie Stebner, a dental and community achiever *par excellence.*

In summary, our Distinguished Member for 1985 is a rugged individualist devoted to the best in dentistry, a person of untold energy and fine technical skills, a devotee of high principles who feared no debate or disagreement, and a true Western character always willing to sacrifice himself to help others.

JAMES VERNETTI

DEPARTMENTS

Book Reviews

THE ART AND SCIENCE OF OPERATIVE DENTISTRY
Second Edition

Editors: Clifford M Sturdevant, Roger E Barton, Clarence L Sockwell, and William D Strickland

Published by C V Mosby Company, St Louis, 1985. 588 pages, indexed; 2326 illustrations. $49.95

This book is an extensive revision of the previous edition published by McGraw-Hill in 1968. Drs Sockwell and Strickland join with Sturdevant and Barton in editing this expanded and revised edition. It is, in fact, not a revision but an entirely new book. With the exception of Dr Greg Smith from the University of Florida, all of the contributors are full-time members of the faculty of the School of Dentistry at the University of North Carolina. They are recognized educators, researchers, and clinicians and bring with them a wealth of experience and talent in putting together this new book.

Although not clearly stated, the authors' intended purpose is to present the practitioner, as well as the dental student, with an organized and carefully illustrated text encompassing all aspects of the field of operative dentistry.

This edition is a significant improvement over the first in the layout of the book itself. The new format is in a two-column, 8½ x 11-inch style which is easy to handle and fits readily on the average book shelf. It is logically sequenced, beginning with an introductory chapter dealing with operative dentistry. In this first chapter, the scope of operative dentistry is presented and useful background information is given that is beneficial to the student and of interest to the dentist, an excellent way to introduce the reader to the subject matter.

Chapter 2 is concerned with dental anatomy, histology, physiology, and occlusion; the following chapter deals with cariology. This logical building from the tooth structure, its function and form, into that of disease and disease control will undoubtedly enable the dental student to better understand what operative dentistry is all about. In the chapter dealing with cariology, current concepts dealing with carious lesions, their etiology, prevention, and control are well reviewed and will be of great benefit to both the student and the practicing dentist.

Chapter 5 on the fundamentals of cavity preparation is superior, organized in such a manner that the student should find it easy to learn nomenclature and cavity classification. Interspersed between cavity classification and that portion of the chapter describing steps in cavity preparation is a section dealing with local anesthetics, analgesia, and the use of mouth props. The introduction of these topics at this point unfortunately breaks the flow of the other pertinent material being presented.

Next, the authors present cutting instruments and the biological considerations and implications of their use. This is followed by the control of moisture. The reader is made aware of the many technics and available materials for the elimination of moisture from the operating field as well as to provide added access and increased operator efficiency. The section on the rubber dam is invaluable and very well illustrated.

Amalgams are presented next, beginning with the class 1 cavity; the class 2 is followed by the 3, 5, and 6 preparations. All are well illustrated, stressing conservation of tooth structure. Matrix applications for the complex amalgams are well presented, giving the reader a very good overview of the various types available. The chapter on pin-retained restorations most appropriately addresses the use of grooves and "dentin chambers" as well as the usage of pins to secure added retention. Like most of the text, these chapters are also exceptionally well illustrated.

Tooth-colored restorations for anterior teeth are described in detail in chapter 11. The authors go beyond most texts in that they show the reader many types of restorations involving all the surfaces of the anterior teeth. The presentation is unusually current, complete, and comprehensive. The chapter following discusses the need for pit-and-fissure sealants and such other forms of treatment as the use of laminate veneers for tetracycline-stained teeth. Also included are a series of color plates showing the cosmetic effects attained with these newer materials and technics. It is quite surprising to see a text, designed primarily for dental students, that includes a section dealing with posterior composite restorations.

The chapter on gold inlays and onlays is one of the highlights of the text. The student and practicing dentist will be able to glean a great deal of useful information from this section. It stresses conservation and the need for reinforcing weakened teeth to prevent their fracture.

The final chapter in the book deals with direct gold restorations. It is the shortest chapter, and the only one not well illustrated. Greg Smith does a superb job, however, of presenting an overview of the use of direct gold material and the class 1, 3, and 5 cavity preparations. He is the one author not from North Carolina.

This text must surely be the best illustrated and the most comprehensive on the subject of operative dentistry available. It is well written, organized in a manner that is easily followed, and is understandable. The references are excellent and add considerable credibility to an outstanding publication which will be equally useful to the dentist and the student. The only serious drawback to this book is the incorporation of the section dealing with posterior composites. Although posterior composite restorations are not, as yet, recommended by the ADA's Council on Materials and Devices, their inclusion in the text tends to lend an endorsement to their use. This reviewer feels that the inclusion of posterior composites detracts a great deal from an otherwise superior text. By including posterior composites, the authors are advocating an unacceptable standard for quality care.

The authors have accomplished their intended goals and have produced an extended reference text, both for the beginner and the practicing dentist. I highly recommend it.

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ADVANCED RESTORATIVE DENTISTRY
Second Edition

Editors: Lloyd Baum and Richard B McCoy

Published by W B Saunders, Philadelphia, 1984. 363 pages; 20 chapters, 21 contributors; indexed; illustrated. $38.00

Dr Richard McCoy joins Dr Baum for this edition. The first edition was published in 1973. The authors' intended purpose, although not stated, is to provide instructional material for graduate dentists which should enable those individuals to adopt new technics and materials as well as to elevate the quality of care in their practice as a result of having read the book. It is obviously not intended to be a rehash of the dental school curriculum but an introduction to newer concepts coupled with preservation of tried and proven methods.

The binding is colorful and the single columns are set in a print that is easy to read. Some chapters are complete with good references and footnotes, while others provide little or no reference substantiation of the material presented. In general, the book is well illustrated with line drawings, charts, graphs, and photographs.

The 20 chapters are logically sequenced beginning with the biological considerations of dental caries. The initial chapter, although well written and providing interesting information, leaves the reader with a question as to what he should do with it. The chapter on intravenous sedation and local anesthesia is a competent review and update and should be of great value to many practicing dentists.

The remaining chapters are concerned with restorative dentistry, beginning with the procedures for primary teeth. Other chapters deal with the treatment of gingival lesions, intermediary bases and cementation, amalgam restorations, retentive pins, direct filling golds, composite resins, expanded uses for visible-light-cured resins, conservation of tooth structure for cast restorations, impression technics, restoration of endodontically treated teeth, atypical preparations for cast restorations, divestment for restorations of cast gold, provisional restorations, the use of base metal alloys, conservative abutment modification for removable partial dentures, gingival health and esthetics, and the resin-bonded retainer for anterior bridges.

This book brings to the dentist a text which will most likely be of considerable value in the everyday practice of dentistry. These 20 chapters compressed into 363 pages provide the reader with clear, concise information and instructions. It is not just a new edition but an entirely new book.

The authors have definitely met their purpose of providing the practicing dentist with useful, pertinent material that is readily understood and easy to implement in the practice. It is a first-rate book, and all of the contributors, as well as Drs Baum and McCoy, are to be commended for putting together this much-needed text for the practicing dentist. Let us hope that the third edition is not as long in coming as was the second.

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Letters

Advantages and Disadvantages of Direct Gold Restorations

Dr L Clark, in his article (*Operative Dentistry,* Winter 1985, **10**, pp 22–37), refers to an antibacterial action of gold foil. His citation is Smith, B B, "Gold foil in everyday practice" (*Dental Clinics of North America,* March 1957, pp 123–137). This is a secondary reference in which Smith had in turn relied on, and misquoted, the original work of Shay, Allen, and Mantz, "Antibacterial effects of some dental restorative materials" (*Journal of Dental Research,* 1956, **35**, 25–32). These investigators did *not* claim innate antibacterial action for gold foil, but opined that any bacteriocidal phenomena associated with foil in their study was due to residual ammonium ions since neither inlay gold nor old gold foil restorations exhibit such action.

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WAYNE E WALCOTT, DDS, MS
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School of Dentistry
Department of Operative Dentistry
Ann Arbor, MI 48109

DR SMITH'S REPLY

This is in regard to the letter from Drs William Gregory and Wayne E Walcott stating that Dr L Clark used a reference from "Gold foil in everyday practice" that was a "misquote" of original work by Shay, Allen, and Mantz, "The antibacterial effects of some dental restorative materials."

Gregory and Walcott are to be complimented on seeking the ultimate **opinion** of the authors regarding probable traces of ammonium ions being responsible for the antibacterial action of freshly prepared gold foil. Shay et al state: "These ions would probably not be present in either *old* gold foil restorations or inlay gold" (*Journal of Dental Research,* 1956, **35**, p 31). Their other statements of interest are:

"Gold foil and copper amalgam showed the greatest over-all action of the materials tested against *Streptococcus viridans,* with copper cement next and silver amalgam third. The addition of sterile saliva to the nutrient agar containing sterile human sera resulted in a decrease of the antibacterial properties of gold foil, inlay gold, and silver amalgam; it resulted in the complete loss of antibacterial action in silicate cement, zinc phosphate cement, and quick-setting acrylic. The saliva tended to enhance the action of copper amalgam and copper cement." (*Ibid*, p 30)

I am delighted if this draws attention to the fine record of service of gold foil for our patients with its excellent tissue response and fine margins. It has even been used in sheet form to assist in the healing of difficult ulcers (see references).

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SCHORR, W F, MOHAJERIN, A H & WENZEL, F J (1966) Gold foil therapy of cutaneous ulcers *Wisconsin Medical Journal* **65** 429–433.

WOLF, J, WHEELER, P C & WOLCOTT, L E (1966) Gold-leaf treatment of ischemic skin ulcers *Journal of the American Medical Association* **196** 693–696.

AUTHOR'S REPLY

I received a notice concerning a letter from two doctors in Michigan, commenting on my article. To substantiate my reference (on p 23) to Dr B B Smith's article and his reference to D E Shay et al, I offer the following statement:

From the 1957 article by Shay et al (p 31), I quote: "The experiments demonstrated that, in most instances, freshly prepared gold foil was an effective antibacterial agent. The experiment of McCue, McDougal, and Shay support this finding." Gold foil was effective against *Bacillus bifermentans* and *Streptococcus viridans,* but was not good against *Lactobacillus casei.* McCue et al (The antibacterial properties of some dental restorative materials, *Oral Surgery, Oral Medicine, and Oral Pathology,* 1951, **4**, p 1180; cited in the quote) stated that the results showed gold foil to be an effective bacteriostatic agent in each of the media used, when testing the material against the test organisms (*Micrococcus aureus* and *Escherichia coli*).

I am not certain why my reference to Dr Smith's statement was questioned, but I believe the two articles I have mentioned above adequately support the point I was making in my article.

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Announcements

Second Course Offered on Direct Gold Restorations

The resounding success of the Continuing Education Course on Direct Gold Restorations, held at Northwestern University Dental School in June 1985, has led to the decision to hold a second course in June 1986 to accommodate the demand.

The course is sponsored by the American Academy of Gold Foil Operators, the Academy of Dentistry, Williams Gold Refining Co, Inc (2978 Main St, Buffalo, NY 14214), the American Dental Manufacturing Co (Box 4546, Missoula, MT 59806), the Hygenic Corp (1245 Home Ave, Akron, OH 44310), and Suter Dental Mfg (632 Cedar St, Chico, CA 95927).

The forthcoming course, to be held June 17-20 at Indiana University School of Dentistry, will as before be structured to include a clinical description of class 1 and 5 direct gold restorative procedures, followed by the performing of these procedures on extracted teeth as well as restorations on clinical patients. At the completion of the course the participants will have completed four class 1 and 5 restorations on clinical patients as well as two similar restorations on extracted teeth.

As a sponsored course, the cost to the participants is subsidized. The registration fee is $100 for members in good standing of the American Academy of Gold Foil Operators, the Academy of Operative Dentistry, or Operative Dentistry faculty in U S or Canadian dental schools.

The registration will be restricted to eight to provide a reasonable faculty-student ratio. All transportation, lodging, meals, and incidental expenses will be the responsibility of the individual or his or her school. Selection of those to participate will be made on May 1, 1986. Selectees will be notified immediately and payment of the $100 registration fee will reserve their place in the course. Those not selected will be given priority for a subsequent course.

You may obtain the application by writing: Dr Julian J Thomas, Jr, Northwestern University Dental School, 240 E Huron Street, Chicago, IL 60611.

NEWS OF THE ACADEMIES

American Academy of Gold Foil Operators

The 35th annual meeting was held 31 October - 1 November 1985 at the University of California and the Hotel Meridien, San Francisco. Clinical demonstrations were given during the morning session of 31 October. During the afternoon the members and guests enjoyed a yacht tour of the Bay Area. The day concluded with a reception and banquet at the Hotel Meridien featuring entertainment by the Golden Gate Dixieland Band and an interesting presentation by J Rodney Mathews, professor emeritus, University of California. The evening concluded with the presentation of the Distinguished Member Award for 1985 to Charles M Stebner of Laramie, Wyoming. The next morning reports and essays were given on the theme of 'Making Direct Gold Even Better'.

The officers of the academy for the forthcoming year are: president, Nelson W Rupp; president elect, Julian J Thomas; immediate past-president, Ronald K Harris; vice president, Allan Osborn; secretary-treasurer, Ralph A Boelsche; and councillors, Richard V Tucker, William H Harris, Michael A Cochran.

Membership in the Academies

Information on membership in the academies may be obtained from the respective secretary.

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(713) 664-3537

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NOTICE OF MEETINGS

American Academy of Gold Foil Operators

Annual Meeting: 15-17 October 1986
University of Puerto Rico
San Juan, Puerto Rico

Academy of Operative Dentistry

Annual Meeting: 12 and 13 February 1987
Westin Hotel
Chicago, Illinois

Press Digest

Effect of placement techniques on microleakage of a dentin-bonded composite resin. Crim, G A & Chapman, K W (1986) *Quintessence International* 17(1) 21-24

The microleakage of a single brand of composite resin, Prisma-Fil LYG (L D Caulk), was studied in relation to the technic of resin placement. Two dentin-bonding agents were used in a total of 80 class 5 cavities prepared in noncarious, unrestored molar teeth. Half of the cavities were prepared on the facial surface and the others on the lingual surface. Butt preparations with 90° cavosurface margins were employed. The cervical margins were placed in enamel for the facial preparations while those of the lingual cavities extended just beyond the cementoenamel junction. All enamel margins were etched. Forty cavities were primed with Bondlite (Kerr Mfg) and the remaining forty with Sinter-bond (Teledyne-Getz). Half of the cavities were filled with the bulk-pack technic and the remainder with a two-stage incremental technic. The restorations were finished and subjected to thermocycling after one hour. From the data presented, there was no significant difference in microleakage between the two technics for restoring class 5 cavities (bulk placement and incremental). All restorations demonstrated some degree of microleakage, particularly at the cervical margin.

INSTRUCTIONS TO CONTRIBUTORS

Correspondence

Send manuscripts and correspondence about manuscripts to the Editor, David J Bales, at the editorial office: OPERATIVE DENTISTRY, University of Washington, School of Dentistry SM-57, Seattle, WA 98195, USA.

Exclusive Publication

It is assumed that all material submitted for publication is submitted exclusively to *Operative Dentistry.*

Manuscripts

Submit the original manuscript and one copy; authors should keep another copy for reference. Type double spaced, including references, and leave margins of at least 3 cm (one inch). Supply a short title for running headlines. Spelling should conform to *Webster's Third New International Dictionary,* unabridged edition, 1971. Nomenclature used in descriptive human anatomy should conform to *Nomina Anatomica,* 5th ed, 1983; the terms 'canine', 'premolar', and 'facial' are preferred but 'cuspid', 'bicuspid', and 'labial' and 'buccal' are acceptable. SI (Système International) units are preferred for scientific measurement but traditional units are acceptable. Proprietary names of equipment, instruments, and materials should be followed in parentheses by the name and address of the source or manufacturer. The editor reserves the right to make literary corrections.

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Submit two copies of tables typed on sheets separate from the text. Number the tables with arabic numerals.

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References

Arrange references in alphabetical order of the authors' names at the end of the article, the date being placed in parentheses immediately after the author's name. Do not abbreviate titles of journals; write them out in full. Give full subject titles and first and last pages. In the text cite references by giving the author, and, in parentheses, the date, thus: Smith (1975) found . . .; or, by placing both name and date in parentheses, thus: It was found . . . (Smith & Brown, 1975; Jones, 1974). When an article cited has three authors, include the names of all of the authors the first time the article is cited; subsequently use the form (Brown & others, 1975). Four or more authors should always be cited thus: (Jones & others, 1975). If reference is made to more than one article by the same author and published in the same year, the articles should be identified by a letter (a, b) following the date, both in the text and in the list of references. Titles of books should be followed by the name of the place of publication and the name of the publisher.

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