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EDITORIAL

Environmental Issues in the Dental Office

In recent years we have seen many changes in our profession. None of these changes has been as profound as the implementation of sterilization and asepsis procedures instituted as a response to the current concern over acquired immunodeficiency syndrome and hepatitis. As a profession, we have not gone along eagerly in this regard. The vast majority of dentists have been compelled to ensure that adequate sterilization and asepsis procedures are carried out in their offices.

Perhaps the most difficult change for many dentists was the use of gloves, face masks, and eye protection. Many still see no reason to comply with these guidelines, which are necessary in today's world. Many dentists use instruments from one patient to the next, with only an alcohol wipe, and others do nothing about the burs and handpieces that are frequently used from one patient to another with no cleaning or sterilization. That may have been permissible in the "good old days," but it is certainly not acceptable in today's world. Patients have a right to know that all materials and supplies used are indeed clean and uncontaminated.

Another important area of asepsis procedures is the use of unit-dosed materials and supplies. Like the use of gloves and masks, using unit-dosed materials and supplies raises the cost of dentistry substantially. The question is: Can we afford not to do this? If you stop to consider the way we use materials and supplies, it is somewhat alarming. If we use cotton pellets, how are they dispensed? How many dentists still use one of the old cotton pellet dispensers, picking up pellets with contaminated cotton pliers? The same goes for reaching in the drawer to get more cotton rolls, 2 x 2s, or other items that come in bulk. What about the handling of impression materials, liners, varnishes, pulp capping agents, and all of the other consumable materials used in patient treatment? Are they handled in an aseptic manner, or do we continue to pick up the impression material tubes from patient to patient with contaminated gloves? Do we use an instrument from a patient being treated to dip into a container of something like Copalite? I could go on and on and the list would seem endless, but the point remains that it is time we use only unit-dosed materials and supplies.

Another change that is being implemented in some parts of this country and that is already mandated in several other countries is how we dispose of our office waste. Office waste placed in a common trash bin will no longer be accepted; there are rules and regulations governing this. What do we flush down our drains? Have you ever stopped to think of the contents of the effluent going into the public sewer system from our oral evacuation system? Other nations have already passed legislation requiring that dental offices have separators on their evacuator lines before those lines are emptied into the sewer lines, to cut down on contamination from dental amalgam, which has a large residual mercury content. Dental offices have been shown to be one of the large contributors of mercury pollution in our water, and we will be required to "clean up our act," forced by legislation to use separators on our vacuum lines.

Change is inevitable. Dentists need to continue to make changes that are costly and often seem unneeded. The time is now for manufacturers to produce unit-dosed materials and supplies. Our profession needs to encourage dentists to install separators in their vacuum lines. It would be nice to see our profession lead the way in this regard, rather than see such a change legislated.

DAVID J BALES
Editor

ORIGINAL ARTICLES

Longevity of Low- and High-copper Amalgams Analyzed by Preparation Class, Tooth Site, Patient Age, and Operator

ROGER J SMALES

Summary

The purpose of this study was to compare the long-term survivals of two low-copper and three high-copper amalgam alloys, and to analyze four clinical factors for their possible effects on the restoration survivals. Some 1476 polished restorations were placed in hospital patients by a large number of operators and assessed over periods of up to 10 years. There were no significant survival differences found among the high-copper alloys and one low-copper alloy, and their survivals were significantly better than for the other low-copper alloy. These results could not have been reliably predicted from the different compositions and creep values of the alloys. A significant effect on restoration survivals was also found with different operators.

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INTRODUCTION

With some exceptions (Osborne, Binon & Gale, 1980; Osborne & others, 1989b; Osborne & Norman, 1990), long-term survival studies of low- and high-copper amalgam alloys have found no significant differences in their longevity despite obvious differences present in their marginal deterioration (Hamilton & others, 1983; Moffa, 1989; Osborne & others, 1989a). Except for class of preparation and surface finish of the restorations (Moffa, 1989), none of the previous studies has investigated any clinical factors which may be related to the survival results for the two different groups of alloys.

In the present long-term study, the survival results over periods of up to 10 years for two low-copper and three high-copper amalgam alloys were analyzed by material, class of preparation, tooth type, patient age, and operator. An assessment was also made of the reasons for the replacement of the various materials.

MATERIALS AND METHODS

Details of the five materials involved are shown in Table 1, while the numbers of restorations assessed are shown in Table 2.

The materials were inserted from 1967 by students and staff in the permanent posterior teeth of eligible patients attending the Adelaide Dental Hospital, and assessed over periods of up to 10 years. The choice of amalgam alloy depended on that in use at the time, with the earlier low-copper alloys being supplanted later by the high-copper materials. Only polished restorations were included in the present study, and no Shofu Spherical restorations were placed by operator RJS (this author).

The longevity of the restorations as influenced by several clinical factors was determined by actuarial life table methods using BMDP Statistical Software, programs 1L and 2L (Dixon, 1990). True failures included repairs and replacements of the restorations from related caries, losses and fractures, but not apparent failures caused by unrelated factors such as extractions for orthodontic and periodontic reasons, access for endodontic treatments, or incorporation into other restorations.

Cavity preparations were classified as class 1, 2, and 5; tooth types as premolars and molars; patient ages as 0-20, 21-40, 41-60, and 61+ years; and operators as operator RJS and all others.

RESULTS

There was a significant difference found in the survival statistics when all five alloys were compared (Table 2). However, on further analysis, there were no significant differences found among the three high-copper alloys, or when this group was compared with a low-copper alloy, New True Dentalloy (NTD) (Table

Table 1. Materials Assessed

Material	Manufacturer	Type and Composition	Initial Hg%	Static Creep* at 7 days
New True Dentalloy	S S White Ltd, Harrow, UK	Fine-cut, pellet 2% Cu, 1% Zn	48%	2.36%
Shofu Spherical	Shofu Dental Co, Kyoto, Japan	Spherical, powder 3% Cu, Zn-free	48%	0.32%
Dispersalloy	Johnson & Johnson Dental Products Co, East Windsor, NJ 08520	Blender, pellet 12% Cu, 1% Zn	50%	0.25%
Indiloy	Shofu Dental Co, Kyoto, Japan	Spheroidal, powder 13% Cu, 4% In, Zn-free	45%	0.06%
Tytin	S S White Co, Holmdel, NJ 07733	Spherical, pellet 13% Cu, Zn-free	44%	0.07%

*Data from Eames & MacNamara (1976)

2, Figs 1 and 2). But, after excluding operator RJS restorations from the number of NTD restorations, a significant difference in the survival of NTD and Shofu Spherical alloys was found (Table 3, Fig 3).

As the survivals of the three high-copper alloys were similar, they were grouped for subsequent assessments of the effects of "class of preparation," "tooth type," "patient age," and "operator" on restoration survival. Analysis of the separate findings for NTD, Shofu Spherical, and the high-copper alloy group showed that patient age had a significant effect for NTD, and that operator had an effect for both NTD and the high-copper group (Table 4). When these same four clinical factors were then tested across the NTD and high-copper alloys, and adjusted for strata, no significant differences were found (Table 5).

For NTD there were 65 true restoration failures and 8 apparent failures, the numbers for Shofu Spherical being 33 and 2 respectively, and for the high-copper group 21 and 14 respectively. There was a significant difference among the three alloy groups for true restoration failures, with relatively more marginal caries being associated with Shofu Spherical alloy (Table 6). When both the true and the apparent restoration failures were combined, then the percentage of failures for NTD was 9.4%, Shofu Spherical 17.0%, and the high-copper group 7.1%.

DISCUSSION

Effects of Materials

Although Dispersalloy tended to show the

Table 2. Abbreviated Actuarial Life Table of Amalgam Alloy Cumulative Survivals

	NTD		Shofu Spherical		Dispersalloy		Indiloy		Tytin	
Interval (Years)	Number Entered	*CS±SE	Number Entered	CS±SE	Number Entered	CS±SE	Number Entered	CS±SE	Number Entered	CS±SE
0-1	774	99(0.4)	206	99(0.9)	144	99(0.9)	268	98(0.9)	84	99(1.5)
1-2	608	98(0.6)	189	96(1.4)	89	99(0.9)	113	96(1.8)	46	93(3.8)
2-3	497	96(0.9)	162	94(1.9)	53	99(0.9)	56	90(3.6)	29	86(5.9)
3-4	391	93(1.2)	124	87(3.0)	34	96(3.7)	42	86(4.8)	23	86(5.9)
4-5	297	89(1.7)	77	75(4.7)	19	96(3.7)	32	86(4.8)	20	81(7.6)
5-6	203	86(2.0)	25	69(6.1)	16	96(3.7)	20	86(4.8)	11	73(10.1)
6-7	141	84(2.3)	21	65(7.1)	15	96(3.7)	16	80(0.7)	9	73(10.1)
7-8	107	75(3.5)	9	42(11.6)	14	96(3.7)	14	80(0.7)	6	73(10.1)
8-9	48	69(4.6)	5	33(12.2)	7	96(3.7)	13	80(0.7)	4	73(10.1)
9-10	25	63(6.7)	3	33(12.2)	2	96(3.7)	9	64(15.4)	—	—

*CS ± SE = Cumulative Survival ± Standard Error of restorations, expressed as percentages

Mantel-Cox = 20.922, df = 4, P = 0.0003 for all five alloys

Mantel-Cox = 5.716, df = 2, P = 0.0574 for the three high-copper alloys

Mantel-Cox = 0.021, df = 1, P = 0.8840 for NTD and the grouped high-copper alloys

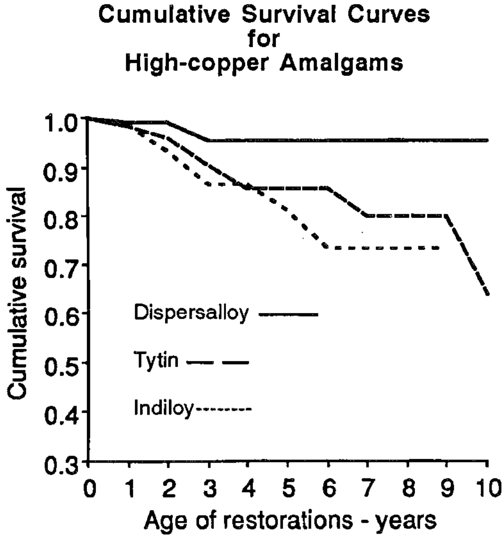

FIG 1. *Survival analysis for the three high-copper alloys*

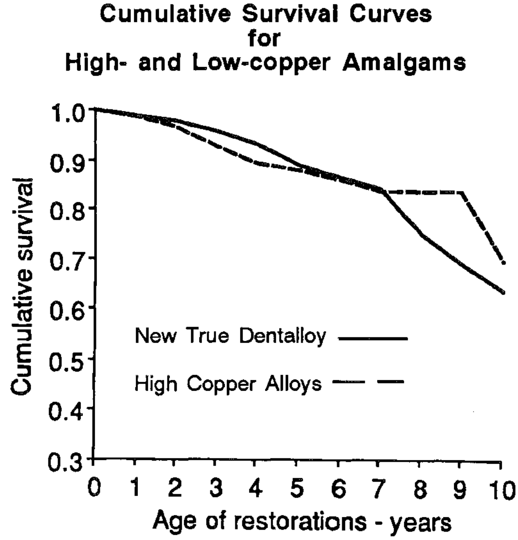

FIG 2. *Survival analysis for New True Dentalloy alloy and the high-copper alloy group*

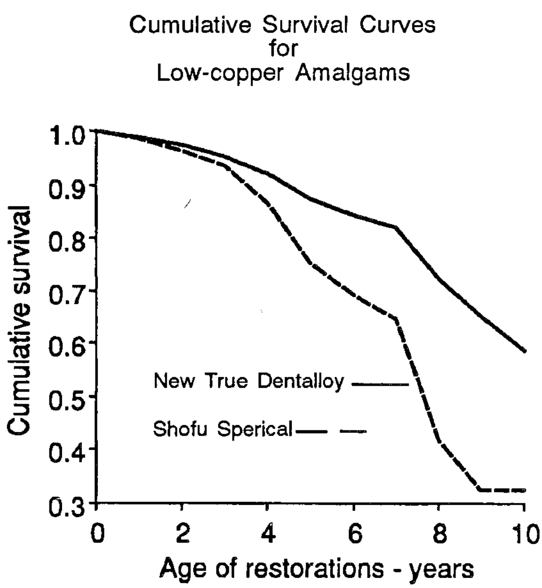

FIG 3. *Survival analysis for New True Dentalloy and Shofu Spherical alloys (operator RJS restorations excluded)*

Table 3. Abbreviated Actuarial Life Table of NTD (Excluding Operator RJS Restorations) and Shofu Spherical Alloy Cumulative Survivals

	NTD		Shofu Spherical	
Interval (Years)	Number Entered	*CS ± SE	Number Entered	CS ± SE
0-1	675	99 (0.4)	206	99 (0.9)
1-2	524	97 (0.7)	189	96 (1.4)
2-3	422	95 (1.0)	162	94 (1.9)
3-4	336	92 (1.4)	124	87 (3.0)
4-5	258	87 (1.9)	77	75 (4.7)
5-6	177	84 (2.2)	25	69 (6.1)
6-7	117	82 (2.6)	21	65 (7.1)
7-8	88	72 (3.9)	9	42 (11.6)
8-9	39	65 (5.3)	5	33 (12.2)
9-10	19	59 (7.8)	3	33 (12.2)

*CS ± SE = Cumulative Survival ± Standard Error of restorations, expressed as percentages

Mantel-Cox = 11.923, df = 1, $P = 0.0006$

Table 4. Actuarial Life Table Statistics Shown Separately for NTD, Shofu Spherical and the Three High-copper Alloys, for Each Clinical Factor

Clinical Factor	NTD		Shofu Spherical		High Coppers	
	Statistic	P	Statistic	P	Statistic	P
Class	3.592	0.17	3.669	0.16	2.926	0.23
Tooth type	1.095	0.30	1.089	0.30	2.758	0.10
Patient age	12.85	0.01*	5.186	0.16	1.669	0.64
Operator	9.214	0.002*	--	--	5.908	0.02*

Mantel-Cox, df = 1

*Significant difference present between components of the clinical factor at the 5% level of probability

Table 5. Actuarial Life Table Statistics for NTD Versus the Three High-copper Alloys Group, for Each Clinical Factor

Clinical Factor	Statistic	P Value*
Class	0.008	0.93
Tooth type	0.104	0.75
Patient age	0.691	0.41
Operator	3.088	0.08

Mantel-Cox (adjusted for strata), df = 1

*No significant differences present between the two groups of alloys at the 5% level of probability

Table 6. Number of True Restoration Failures over the Study Period

Material	Replaced or Repaired	Fractured or Lost	Marginal Caries	Total
NTD	46	15	4	65 (8.4)
Shofu Spherical	10	10	13	33 (16.0)
High coppers	11	8	2	21 (4.2)

Percentage of total restorations shown in parentheses

$\chi^2 = 23.6446$, df = 4, $P < 0.001$

least failures, there were no significant differences found in the long-term survivals among the three high-copper alloys (Table 2). Other studies have also reported similar findings for various high-copper non-gamma-2 alloys (Osborne & others, 1989b; Osborne & Norman, 1990). However, long-term amalgam survival studies have reported variable findings when comparing low- and high-copper alloys (Osborne & others, 1980; Hamilton & others, 1983; Moffa, 1989; Osborne & others, 1989a, 1989b; Osborne & Norman, 1990).

In the present study, one low-copper alloy (NTD) performed as well as the three high-copper alloys, while another low-copper alloy (Shofu Spherical) performed significantly worse (Tables 2 & 3). Comparison of the 10-year survivals of the study with the findings of another study over the same period showed survivals for NTD of 78%, Shofu Spherical 47%, Dispersalloy 91%, Indiloy 89%, and Tytin 84% (Letzel & others, 1990). The pattern of alloy survivals was similar too, but better than that of the present study. However, in the other study only a few skilled operators were involved, and the materials were all placed under controlled clinical trial conditions in a highly-motivated and restricted patient population (Letzel & others, 1989).

In the present study, no correlation was found between the alloy survivals and their seven-day static creep values (Table 1). Although the creep values for Shofu Spherical and Dispersalloy were similar, their restoration survivals were not, and the high creep value for NTD was not reflected in any lower restoration survivals than for Indiloy or Tytin, which both had very low creep values. Despite a long-term reduction in the initially high creep values for silver-tin amalgam alloys (Bryant, 1980), the inability of static creep tests to universally predict restoration longevity has also been demonstrated elsewhere (Osborne & Norman, 1990).

Despite its low creep, Shofu Spherical restorations have been shown to have an early, high marginal deterioration rate (Jordan, Suzuki

& Mills, 1978; Osborne & others, 1978), while the early marginal deterioration rate for the high-creep alloy NTD has been shown to be low and similar to Dispersalloy (Jordan & others, 1978). The use of an alternative cyclic bending creep-fatigue test has shown very little marginal fracturing for either NTD or Dispersalloy, but extensive fracturing for the more brittle Tytin (Williams & Cahoon, 1989).

Increased marginal deterioration of amalgam alloys has also been related to the presence of gamma-2, the absence of zinc, and a high initial mercury content (Beech, 1982; Berry, Osborne & Hatch, 1986). Both NTD and Shofu Spherical alloys contain gamma-2, while the three high-copper alloys assessed do not. Zinc is also absent in the Shofu Spherical, Indiloy, and Tytin alloys, and Dispersalloy has the highest initial mercury content (Table 1). However, as with static creep tests, the relationship between these three factors and alloy survival is again not universally predictive, as shown by the results of the present study.

Effects of Clinical Factors

Little information is available from long-term clinical studies on the factors that may be related to the survival results for different amalgam alloys. Of the four clinical factors assessed in this study, only the effects of patient age were significant with NTD, and the effects of operator for NTD and the high-copper alloy group (Table 4). By contrast, one other study found significant survival differences between class 1 and 2 preparations, but not between polished and unpolished restorations (Moffa, 1989).

Although there were also no significant effects of tooth type on survivals in the present study, one study reported that amalgam restorations in lower premolars had a high tendency to fail (Peters, Letzel & van't Hof, 1990).

The most significant effect on restoration survival in this study was that of the operator, especially for NTD. An operator effect was not found in one other long-term study (Peters & others, 1990), but has been reported to be of significance in shorter-term studies involving NTD and Dispersalloy (Letzel & others, 1989).

Reasons for Failure

The number of true restoration failures for the different alloys are shown in Table 6. In many instances it was not possible to determine the reasons for restoration failures from the patient records, and so these failures were entered under the category of "Replaced or Repaired." Therefore, the reasons for the failures could not be compared with those reported in other studies, and the classification of failure types also differs from other studies.

In this study, Shofu Spherical alloy had the highest percentage of true failures, and the high-copper alloy group the lowest. Combining the true and apparent restoration failure types gave similar failure results for both NTD alloy and the high-copper alloy group, which were approximately half that found with Shofu Spherical alloy.

CONCLUSIONS

For the two low- and high-copper amalgam alloys assessed over periods of up to 10 years in this study, it was concluded that:

1. There were no significant restoration survival differences found among three high-copper alloys (Dispersalloy, Indiloy, and Tytin), or between this group and a low-copper alloy, New True Dentalloy (NTD).
2. However, the restoration survivals of these alloys were significantly better than that of another low-copper alloy, Shofu Spherical.
3. Neither the alloy composition, initial mercury content, or static creep values of the alloys accurately predicted the long-term restoration survivals.
4. Of the four clinical factors analyzed for possible effects on restoration survivals, only patient age was significant for NTD, and operator for both NTD and the high-copper group.
5. Shofu Spherical alloy restorations had failures of 17.0%, which was approximately twice that for NTD and the high-copper group.

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Comparison of Air-dried Treatments after Etching on the Micromechanical Bonding of the Composite to Ionomer Surface

M HOTTA • K KONDOH
K YAMAMOTO • K KIMURA

Summary

Comparisons of air-dried treatments after etching on the micromechanical bonding of the composite to ionomer surface were made and clinical recommendations are provided. This in vitro study was made to evaluate the adhesion of the interface with a composite resin/bonding agent followed by air-drying surface treatment. The most effective surface conditions were found in the drying treatment groups. Non-air-dried (wiped dry with a tissue) surface groups were less effective.

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INTRODUCTION

Glass-ionomer cements are frequently used as a cavity liner under composite resin restorations in the so-called sandwich technique (McLean & Wilson, 1977; McLean & others, 1985). Glass-ionomer cement surfaces have been reported as unstable, and crack formation on the cement was reported to be caused by etching and/or air-drying (Smith, 1988). Studies of composite resin bonded to etched and air-dried glass-ionomer cement surfaces have not clearly identified the technic to obtain optimal tensile bond strength. The purpose of this study was to evaluate the tensile bond strength of composite resin to the glass-ionomer cement surface, with and without compressed air-drying after acid-etching. A second purpose of the study was to evaluate with scanning electron microscopy the bonding/cement interface and to characterize with SEI (secondary electron images) the fracture surface following the tensile bond test.

MATERIALS AND METHODS

Specimens were prepared in three groups for tensile testing of the glass ionomer, testing of the tensile bond strength of the resin to glass ionomer, and for scanning electron microscopic evaluation of the interface of the bonding area. The materials used were: Ketac-Cem (ESPE, Seefeld, Germany), a glass-ionomer cement, and Palfique Light (Tokuyama Soda Co, Ltd, Tokyo, Japan), a light-cured anterior-posterior composite resin. Six specimens were prepared for each test variable.

Tensile Bond Strength Test

The glass-ionomer cement (Ketac-Cem) was mixed according to the manufacturer's instructions and inserted into teflon molds (4 x 4 x2 mm). The glass-ionomer specimens in each of the three groups underwent different conditioning procedures before bonding to the composite resin (Table 1). The samples in group A were not etched, they were washed and either wiped dry with a tissue or dried for 30 seconds with an air pressure of 1.6 kgf/cm^2. The air syringe was held 5.0 mm from the surface of the glass-ionomer cement. The samples in group B were treated with 37% phosphoric acid gel etchant for 10 seconds, followed by rinsing under running tap water for 20 seconds, and either wiped dry with a tissue or air-dried for 30 seconds. The samples in group C were treated with 37% phosphoric acid gel etchant for 20 seconds, followed by washing thoroughly for 20 seconds, and wiped dry with a tissue or air-dried for 30 seconds. The conditioned samples were held in an alignment device for bonding, and an unfilled bonding agent (Palfique Light) was placed on the surface. An empty cylinder (3 mm in diameter) was placed over the primed surface and filled with composite resin. The light-cured composite resin was cured by exposure to two separate 60-second cycles, with the light directed from two positions 180° apart around the circumference of the bonding plane (Fig 1). All the samples were immersed in a water bath for 24 hours at 37 °C before testing. Following the storage period, tensile tests for bonding strength measurement were performed with a crosshead speed of 0.5 mm/min using a Universal Testing Machine (Autograph, AGS-500A, Shimadzu Mfg Co, Kyoto, Japan) in air at 23 ± 1 °C and 50 ± 10% relative humidity. Bond strengths were calculated as the load at failure divided by the interfacial area of bonding. Differences in adhesion values for each set of test conditions were subjected to Student's *t*-test to determine the level of significance. A level of $P > 0.05$ was regarded as not significant.

Table 1. Sample Groups

A	A0	Cements were not etched; they were wiped dry with a tissue.
	A1	Cements were not etched; they were dried for 30 seconds.
B	B0	Cements were etched for 10 seconds and wiped dry with a tissue.
	B1	Cements were etched for 10 seconds and dried for 30 seconds.
C	C0	Cements were etched for 20 seconds and wiped dry with a tissue.
	C1	Cements were etched for 20 seconds and dried for 30 seconds.

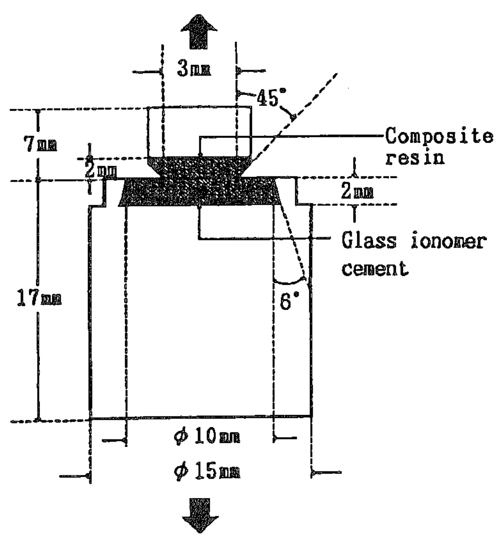

FIG 1. *Diagram of the specimen for tensile bond strength measurement*

Tensile Strength

The tensile strength of the glass-ionomer cement itself was evaluated by the direct pull method. The cement was mixed according to the manufacturer's instructions and transferred to the specimen cup with plastic instruments. Six specimens were prepared and stored in water at 37 °C for 24 hours. The rod with the attached specimen was locked into position (Fig 2). Direct tensile strengths were performed with a crosshead speed of 0.5 mm/min using a Universal Testing Machine in air at 23 ± 1 °C and 50 ± 10% relative humidity. Tensile strength was calculated as the load at failure divided by the cohesive fracture of the cement.

SEM Observation

Glass-ionomer samples were examined in the scanning electron microscope to evaluate the surface for mechanical bonding. Scanning electron microscopy was carried out for each group at the bonding/cement interface utilizing BEI (back-scattered electron images). Specimens for each of the three groups were embedded in acrylic resin and sectioned vertically after 24 hours storage at 37 °C in distilled water. The samples were then transferred to a scanning electron microscope (JSM T200, JEOL, Ltd, Tokyo, Japan) operating at 15 kv accelerating voltage for visual analysis.

On completion of the bond test, the fracture surfaces were examined with the scanning electron microscope. Characterization of the fractured surface after the tensile bonding test was observed with SEI (secondary electron images) using a replicating technique. The samples were attached to SEM stubs and examined after sputter-coating with gold. SEM examination involved inspection and photographing of the average surface structure at magnification X500.

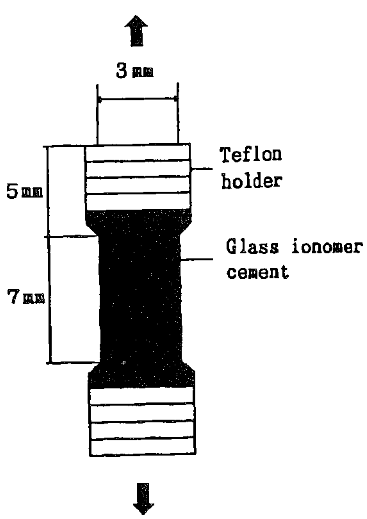

FIG 2. *Size and shape of the tensile strength specimen*

RESULTS

Tensile Bond Strength

Values for the bond strengths of the resin to these surfaces are presented in Table 2. The data from all samples were tabulated, recorded, and analyzed statistically, using the analysis of the *t*-test. These values represent the mean of six results. As can be seen from Table 2, no significant difference was obtained for any surface for two of the conditions under test. However, bond strengths tended to increase when air-dried groups were compared with non-air-dried (wiped with a tissue) group samples. The use of air-drying proved to be effective.

The direct tensile strength of the glass-ionomer cement used in this study has been found to be about 35 kgf/cm².

Table 2. Results from the Tensile Bond Strength of the Glass Ionomer/Composite Interface and the Tensile Strength of the Glass-Ionomer Cement

Tensile bond strength		Significant level (*P*)
A0	2.0 ± 1.4	
A1	3.7 ± 1.7	> 0.05
B0	27.6 ± 7.0	
B1	31.4 ± 4.9	> 0.05
C0	35.7 ± 5.7	
C1	35.9 ± 5.6	> 0.05

Tensile strength

35.3 ± 2.1 Unit: kgf/cm², Mean ± SD, N = 6

SEM Observation

Evaluation with SEM showed little difference in the surface morphology of the two differently dried surface samples. The non-air-dried (wiped dry with a tissue) sample of the micrograph shows that the bonding/cement interface is smooth and slightly rough. There is very close contact between the cement and bonding agent. However, in air-dried samples, bonding agents actually penetrate into the surface crack of glass-ionomer cement. It is supposed that the depth of bonding layer is about 50-200 μm (Fig 3). By air-drying, microfissures (cracks) are created in the surface, thus facilitating the bonding of resin by micromechanical attachment.

Fractured surfaces in acid-etched samples after the tensile bond test showed that failure always occurred cohesively within the cement and not at the interface. However, the non-etched surface showed interface failures, which would weaken the adhesive joint (Fig 4).

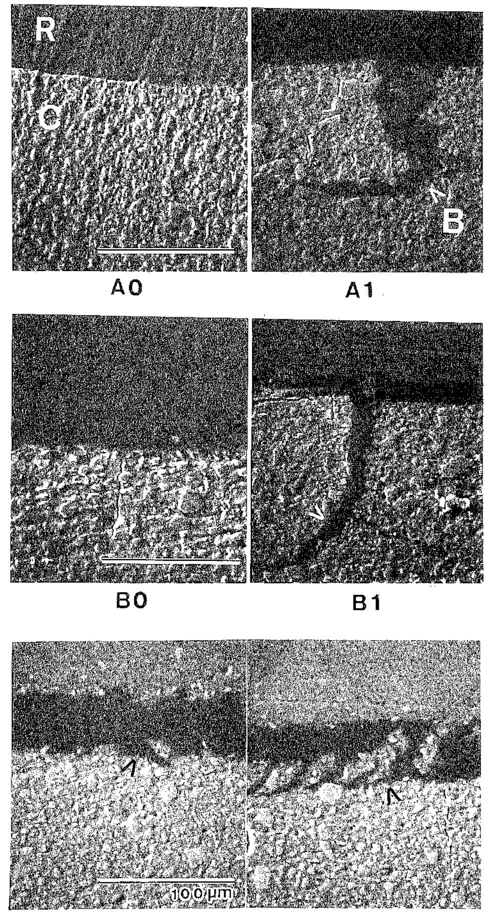

FIG 3. *BEI image of etched and non-etched Ketac-Cem/Palfique light interface with an intermediate layer of the dental adhesive (X270; R = resin, B = bonding, C = cement)*

DISCUSSION

The composite resin bonding to the glass-ionomer interface is achieved by mechanical bonding. Gross mechanical retention can be produced by etching glass-ionomer surfaces (Subrata & Davidson, 1989). The addition of drying to the procedure, however, created micromechanical retention sites, which seemed to improve retention. There was no difference between the microstructural appearance of the two drying treatments. Apparently the air-drying for 30 seconds occurred to 200 μm deep on the resin tags. It has been suggested that the formation of bonding agent tags provided mechanical retention to the glass-ionomer cement. Cracks in the surface of glass-ionomer cement were caused by air-drying after acid-etching (Hotta & others, 1990). Tag formation was observed at the cement/bonding interface where the crack was occurred. It is indicated from the above findings that crack formation will improve the adhesion, provided that the cement liner remains bonded to the dentin. In a study, the bond strength of composite resin to cement was decreased substantially by the procedure (Smith & Söderholm, 1988). However, attachment is caused by tags of resin mechanically interlocking in etched fissures and dried cracks of glass-ionomer cement. It is recommended that for the best bonding of composite to glass-ionomer cement, the surface should be cleansed, acid-etched, and thoroughly air-dried for 30 seconds.

SEM observations of the fractured glass-ionomer cement surface revealed that fracture occurred, however, through the cement matrix as well as the matrix/core interface. In these cases, failure was always observed to be cohesive, so that the factor limiting bond strength

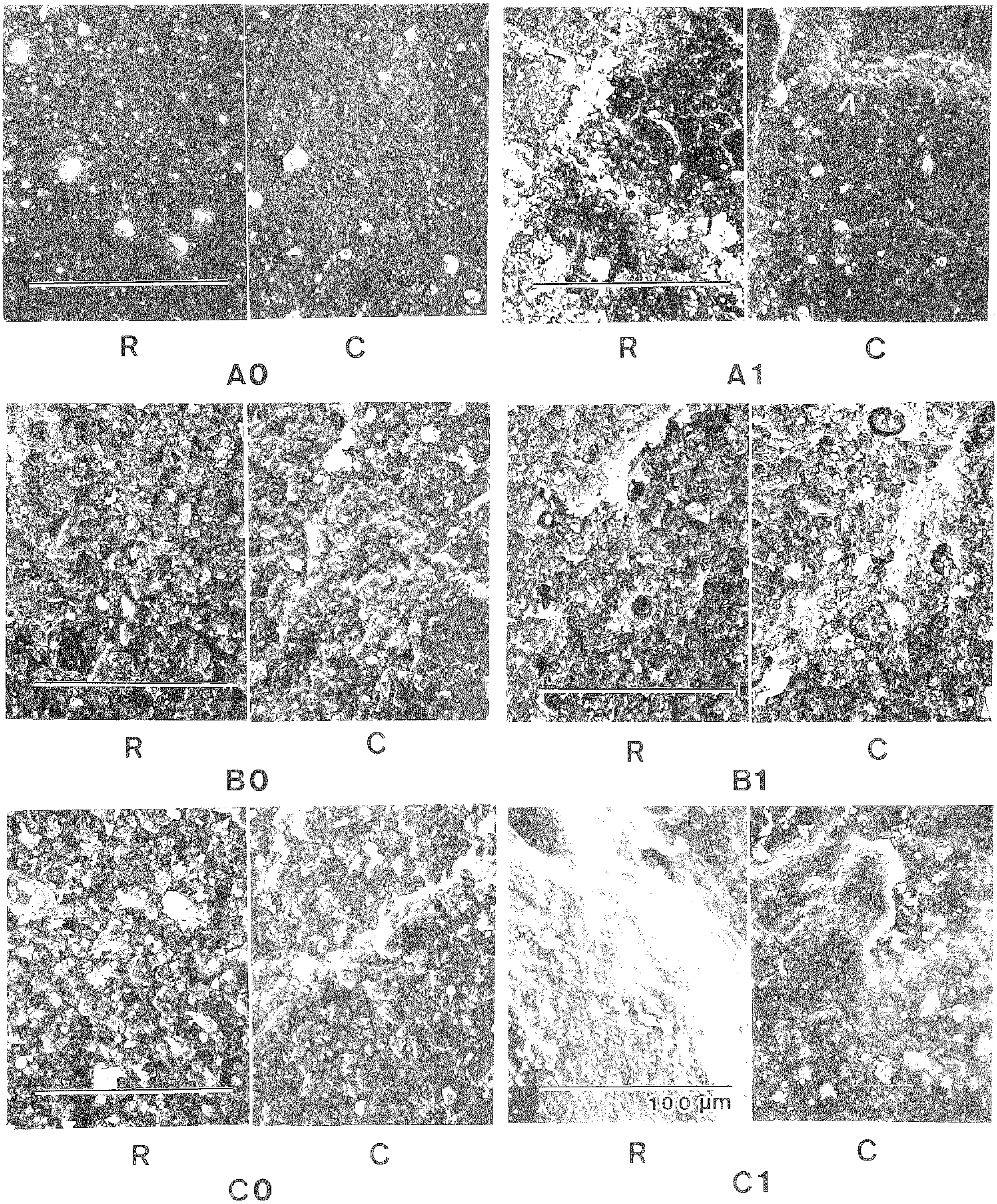

FIG 4. *SEI image of the fractured surface after tensile bond strength test (X400; R = resin side, C = cement side)*

is the intrinsic tensile strength of the cement. From this it can be asserted that the maximum bond strength possible with this version of the glass-ionomer cement has been attained.

CONCLUSION

Based on the results of this study, the adhesion of composite resin/bonding agent to glass-ionomer cement is affected by air-drying, particularly at the interface. The least amount of adhesion was found with the non-air-dried (wiped dry with a tissue) specimens.

Acknowledgement

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The Influence of an Adhesive System on Shear Bond Strength of Repaired High-copper Amalgams

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Summary

The shear bond strengths of intact high-copper spherical and admixed amalgams were compared with repaired high-copper spherical and admixed amalgam specimens with and without the use of an adhesive system (Amalgambond). In the spherical group the shear bond strength of the repaired specimens was found to be 55 and 53.2% of the intact specimens without and with the use of the adhesive system. After thermocycling those percentages were 48.5 and 43. In the admixed groups those percentages were 39, 36.5, 34.5, and 35.2 respectively. It was found that the application of Amalgambond did not significantly increase the strength of the repaired amalgam. Thermocycling only had a significantly adverse effect on the repair strength in the admixed group repaired without an adhesive system.

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Introduction

Amalgam restorations that have fractured, or where recurrent caries has rendered a portion of them defective, can be treated by either complete removal and replacement or repair of the defect. Repair of the restoration may be a viable alternative if sufficient strength at the repaired interface can be achieved.

Various studies on the strength of repaired amalgam present different conclusions, which are summarized in Table 1.

Variables which may affect the degree of bond strength of a repaired amalgam restoration are: types of amalgam alloy used, surface treatments of the aged amalgam, age differences between old and new amalgam, and test methods employed. A 4-methacryloexyl trimellitate anhydride (4-META)-based adhesive system (Amalgambond, Parkell, Farmingdale, NY 11735) has been promoted to bond fresh amalgam to an existing amalgam restoration.

The purpose of this study was to measure the shear bond strength of repaired high-copper spherical and admixed amalgam alloys and to determine whether significant differences existed when an adhesive system was applied.

Materials and Methods

Two types of non-gamma-2 amalgam alloy were used in this study: precapsulated spherical alloy (Tytin, Sybron/Kerr, Romulus, MI 48174) and precapsulated admixed alloy (Cluster, Sybron/Kerr). They were triturated in a Varimix III amalgamator (L D Caulk Co, a Division of Dentsply International, Inc, Milford, DE 19963) according to the manufacturer's instructions for time and speed.

A two-piece stainless steel split die assembled in a supporting frame, similar to a die employed by Hibler and others (1988), was used to make cylindrical amalgam specimens (Fig 1). The die could be adjusted to make specimens with a diameter of 4 mm and a length of either 4 mm or 8 mm.

The amalgam was manually condensed into the mold, using a round-faced condenser. The spherical alloy was condensed with a 2 mm-diameter condenser and then admixed with a 1.5 mm-diameter condenser. Each alloy was condensed with different amounts of condensing pressure in regard to the characteristics of the alloy. The amount of condensation pressure was not standardized because generally spherical amalgam was condensed better under lower condensation force compared to admixed amalgam. During condensation, care was exercised to remove excess mercury before another increment was added. The die was overfilled and excess amalgam was carved. The specimens were left in the mold for one hour and then carefully removed. A total of 20 spherical and 20 admixed specimens with a diameter of 4 mm and a length of 4 mm were fabricated and stored at room temperature for 10 days. Ten control specimens of both spherical and admixed types of amalgam (diameter 4 mm, length 8 mm) were made

Table 1. Summary of Strengths of Repaired Amalgam Previously Reported

AUTHORS	CONCLUSIONS
Terkla, Mahler & Mitchem (1961)	< 50% of intact
Kirk (1962)	23 to 98% of intact
Jorgenson & Saito (1960)	comparable to intact
Scott & Grisius (1969)	39 to 70% of intact
Nettelhorst (1977)	30 to 60% of intact
Fukuba & others (1977)	comparable to intact
Consani, Ruhnke & Stolf (1977)	15 to 34% of intact
Berge (1982)	12 to 51% of intact
Walker & Reese (1982)	< 50% of intact
Hornbeck, Duke & Norling (1986)	29 to 56% of intact
Brown & others (1986)	41 to 87% of intact
Gordon & others (1987)	≤ 50% of intact
Hibler & others (1988)	33 to 67% of intact
Erkes, Burgess & Hornbeck (1990)	17 to 31% of intact
Hadavi & others (1990)	50 to 79% of intact

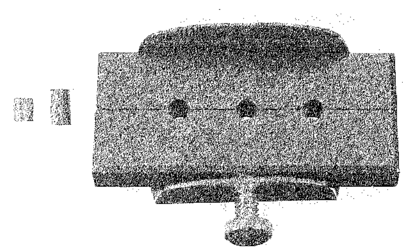

FIG 1. *Stainless steel split die with fabricated specimens*

following the procedure and stored for 30 hours at room temperature.

After storage one end of the 4 mm-long test samples was roughened with a #700 low-speed carbide bur (Jet, Beaver Dental Products, Ltd, Morrisburg, Ontario, K0C 1X0). The split die was coated with Copalite (Cooley & Cooley, Ltd, Houston, TX 77266) and thoroughly thinned with a stream of air to ease the removal of the specimens after repair. The specimens were placed back at the bottom of the die for repair. In half of the specimens (10 in each amalgam group), Amalgambond was applied according to the manufacturer's instructions 10 seconds before fresh amalgam was added. The other specimens did not receive any further treatment. The specimens were repaired with the same kind of amalgam, using the same condensation technique as described before, producing a new sample (diameter 4 mm, length 8 mm) with the bond between old and new amalgam located at the center of the rod. The specimens were left in the die for one hour and were then carefully removed to be stored at room temperature for 24 hours. All samples were made by the same operator.

The samples in each test group were divided in half, each consisting of five samples. One half was thermocycled for six hours at 4 °C and 60 °C with dwell and transfer periods of 30 seconds; the other half was left at room temperature for an additional six hours.

All rods were mounted in epoxy resin (Buehler Ltd, Evanston, IL 60204) with the joined surfaces perpendicular to the axis of the sample. The samples were placed in a Universal Testing Machine (J J Lloyd Instruments, Southampton, England), to be subjected to a load force with a crosshead speed of 0.01 inch/min until fracture occurred. The unrepaired control specimens were similarly fractured 30 hours after condensation. The peak load values at fracture were collected by a digital readout. Shear bond strengths were calculated as maximum load per cross-sectional area of bonded surface (MPa), that did not consider distance between support, dimensions, or geometry of the specimen. The fractured surface of the repaired specimens were examined under a light microscope. Statistical evaluation was done by a Student *t*-test.

Results

The results are presented in Table 2 and

Table 2. Mean and Standard Deviation of Shear Bond Strength in Different Test Groups (MPa)

	SPHERICAL			ADMIXED		
	control	**am+am**	**am+AMB+am**	**control**	**am+am**	**am+AMB+am**
NOT THERMOCYCLED	14.64	7.12	7.85	12.00	4.78	4.38
	±2.84	±2.14	±1.00	±0.84	±0.34	±0.41
THERMOCYCLED	15.24	10	6.57	11.86	4.14	4.17
	±1.51	±1.38	±2.11	±0.92	±0.67	±0.66

am+am = test group repaired without adhesive system

am+AMB+am = test group repaired with adhesive system

Figures 2, 3, and 4. The shear bond strengths of all repairs were less than that for fracture through the intact amalgam. The strongest repaired specimens were made of spherical alloy. The shear bond strengths of specimens in all spherical test groups, except the control group without thermocycling, were significantly higher than that of the admixed specimens ($P \leq 0.05$). The intact spherical amalgam specimens showed a higher strength after thermocycling, but the difference was not found to be significant ($P = 0.43$). A higher strength was found when Amalgambond was utilized to repair spherical amalgam, but this result was not found to be significantly different from the specimens repaired without the adhesive system ($P = 0.77$). The shear bond strength of the repaired specimen without the adhesive system was 39 and 34.5% for the admixed alloy, and 51 and 48.5% for the spherical alloy without and with thermocycling respectively. For the Amalgambond specimens the percentages were 36.5, 35.2 for the admixed alloy, and 53.6 for spherical alloy without thermocycling and 43.1 with thermocycling. Only in the admixed group repaired without an adhesive system did thermocycling have a significantly adverse effect on the repair strength ($P < 0.05$).

On microscopic examinations of the fractured surfaces in the test group treated with Amalgambond, it appeared that in the admixed and spherical samples the failure occurred in the fresh amalgam, except in two samples in

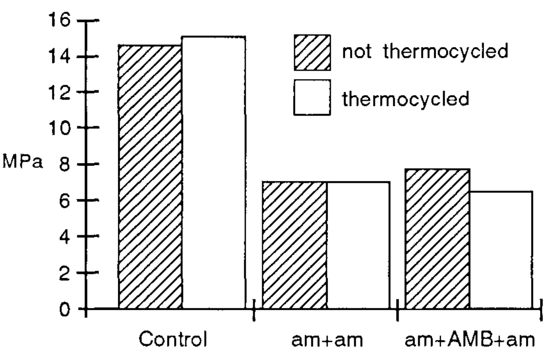

FIG 2. *Shear bond strength in the spherical test groups*

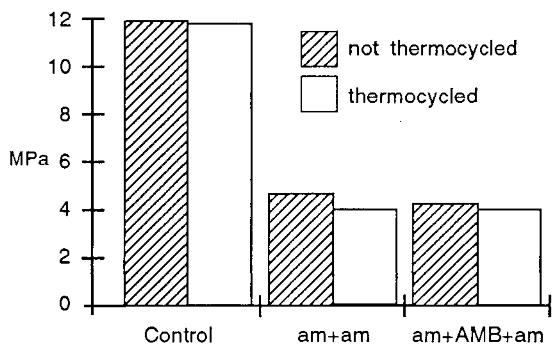

FIG 3. *Shear bond strength in admixed test groups*

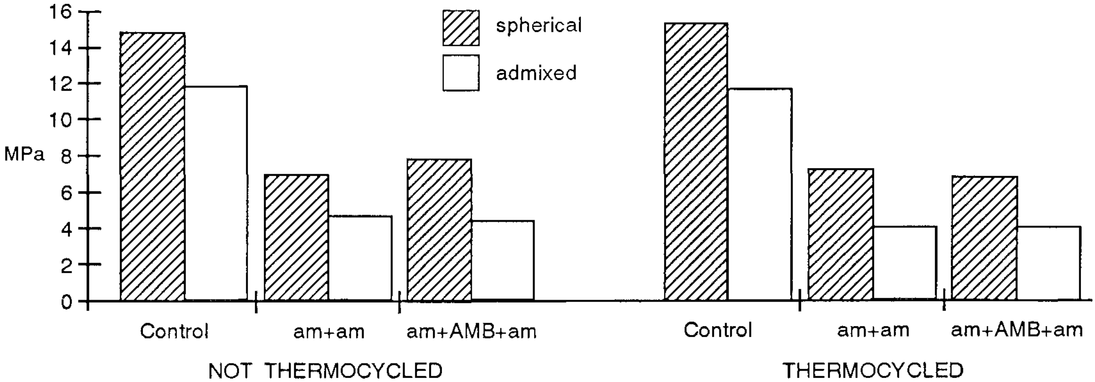

FIG 4. *Comparison of non-gamma-2 spherical and admixed specimens*

the spherical group (one thermocycled and one nonthermocycled), where the fracture occurred partly in new and partly in old amalgam.

Discussion

The present in vitro study did not show any significant difference in shear bond strength between amalgam specimens repaired with or without an adhesive system. Amalgambond is a 4-META-based material that has been introduced to bond fresh amalgam to tooth structure and/or existing amalgam (Swift, 1989).

The results of this study showed a shear bond strength of the repaired specimens of around 50% of the control in the spherical group and of approximately 35% in the admixed group. Nettelhorst (1977) found that alloys with spherical particles gave slightly stronger repairs than admixed alloys, which is consistent with our findings.

Most studies of repaired restorations do not evaluate the effects of thermal stress on the repair. In a study by Reitz and Mateer (1966), it was noted that thermocycling was associated with crack formation along the junction between old and new amalgam. Erkes, Burgess and Hornbeck (1990), however, concluded that thermocycling had no effect on the flexural strength of the repaired amalgam, which corresponds with our findings in the spherical amalgam group.

Kirk (1962) mentioned that the bond between aged and new amalgam is a result of the mercury of the fresh mix dissolving into the set amalgam. In cases where an adhesive system is used, this may prevent the reaction between the free mercury and the old amalgam, and the strength would depend on the bonding between amalgam and adhesive system. Tanaka and others (1981) stated that oxidation of alloy surfaces increases adhesion, indicating that 4-META resin bonds more strongly to the metal oxide than to the metal itself. This would suggest that the age and type of the existing amalgam can play a significant role.

Staehle and others (1988) evaluated the shear bond strength of amalgam to tooth structure using a 4-META-based bonding agent and noticed that in some test samples the fracture occurred in the amalgam and not in the bonding area. In our study all admixed samples broke in the fresh amalgam, and in the spherical group in two cases the fracture occurred partly in new and partly in the old amalgam. This may indicate that Amalgambond adheres more strongly to aged amalgam, but affects the setting of fresh amalgam, thus creating an area of weakness.

Most previous studies reported that repaired amalgam has lower strength than an intact specimen (Table 1). The comparatively lower strength of the repaired Amalgambond specimen found in this study also suggests that when fresh and aged amalgam are joined, the use of an adhesive system does not provide the strength of an intact specimen. Added retentive features which enhance mechanical retention are still critical to the long-term success of the completed restoration.

The effect of mercury pretreatment has been evaluated in several studies with mixed results. Some investigators achieved higher repair bond strength (Terkla, Mahler & Mitchem, 1961; Jorgenson & Saito, 1960; Scott & Grisius, 1969; Hornbeck, Duke & Norling, 1986), but other studies showed no significant improvement in strength after mercury pretreatment (Hibler & others, 1988; Erkes & others, 1990). With regard to mercury hygiene and possible toxic effect in daily practice, we did not consider such a treatment appropriate, and it is therefore not included in our evaluation.

Conclusions

This in vitro evaluation of the shear bond strength of repaired amalgam showed that a repaired amalgam is inferior to an intact one. The shear bond strength of repaired amalgam was higher when spherical amalgam was used, but the use of an adhesive system did not increase the strength. In clinical practice careful evaluation is necessary before repairing an existing amalgam restoration, and mechanical retentive features must be added to adjacent tooth structure and remaining, well-secured amalgam sections.

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Evaluation of a New Intraoral Isolation Device

M A CHAMPION • G KUGEL • C GRUSKOWSKI

Summary

Control of moisture is critical in the oral cavity to obtain the optimal properties of dental materials and thus increase their longevity. The conventional rubber dam is a 6" x 6" latex sheet held in place with a separate frame. This study evaluated a new moisture control device that is self-supported by a rolled spring border. Twenty-four patients seen by 24 different dental operators and six dental assistants, with previous experience using the conventional rubber dam, participated. The study concluded that there was significant improvement in user acceptance and patient comfort with the use of this isolation device and, from the compilation of remarks from questionnaires, it was concluded that it was most effective for completion of anterior teeth restorations.

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Introduction

Since its introduction in 1864, the rubber dam has ensured complete dryness of the teeth and improved the quality of clinical restorative dentistry (Blackwell, 1947; Mosteller, 1961; Phillips, 1982; Prime, 1937). Only in a dry field can the dentist best perform all procedures of cavity preparation: caries removal, placement of necessary liners and bases, and final placement of the restorative filling material. The exclusion of moisture is critical to obtain the optimum properties of restorative materials. These procedures are completed without contamination by oral fluids, particularly essential in endodontic therapy, and the dam provides improved visibility (Dinin, 1951) and access to the working field.

The rubber dam protects the patient from the possibility of swallowing hazardous debris and small instruments, such as root canal files and those associated with pin placement. The operator is protected from infectious agents that may be present in the patient's mouth. As well as protecting the soft tissues from harmful effects of medications, the dam retracts the marginal gingiva and thus better exposes the cavity preparation, and retracts lips, cheeks and tongue. When teeth are isolated well, the need for the patient to rinse and expectorate is eliminated. This allows the operator to work more efficiently and save time, thus the operator is more productive.

The use of the rubber dam makes the operator's task easier, the operation more comforable for the patient, and promotes the highest possible quality of dental service.

The conventional method of moisture control is with a 6" x 6" latex rubber dam held in place with clamps and a separate frame. This new isolation device, the Quick Dam (Auckland Co, Cary, NC 27511), is smaller than the conventional rubber dam, approximately 4 1/2" x 2 1/2", and is supported intraorally by a rolled spring border-flex ring (Fig 1).

The Quick Dam is available in three sizes—small, medium, and large—and it is important to choose the appropriate size for the patient. The flex ring must fit buccal to the teeth and form a seal with the walls of the cheek. Before insertion, the Quick Dam is folded by a method that is easy to learn. The company notes that, should the patient have a strong gag reflex, it may be overcome by showing the patient how to fold and place the dam and letting the patient install it. After the Quick Dam has been inserted into the mouth, dental floss is used to push the material between adjacent teeth that are to be isolated.

Materials and Methods

The study of this device was undertaken at Tufts University School of Dental Medicine in the Dental Auxiliary Clinic. Senior dental students rotate on a weekly basis through this clinic and are supported by trained dental assistants. The students have had experience in the application of conventional rubber dams for up to two years. The dental assistants have all had considerable experience with the placement of conventional rubber dams. Working together, the dental student and assistant applied the Quick Dam (although it is readily applied by one operator); it was felt that, without the need of adjusting extra frames, this dam could be applied more quickly than conventional dams, particularly for work on anterior teeth. Twenty-four cases were documented, using patients who had previous experience with the conventional rubber dam.

The device was used intraorally and held in place by a flexible outer ring, thus eliminating the need for additional support. The dam is to be made in three sizes, small, medium, and large, but only the medium size was used in this study. The latex material is eight to 10 mils (0.008" to 0.010") thick, corresponding to a medium- to heavy-weight rubber dam. The Quick Dam was placed flat on one hand with the rolled border uppermost, facing the operator. Using the thumb and the first and second

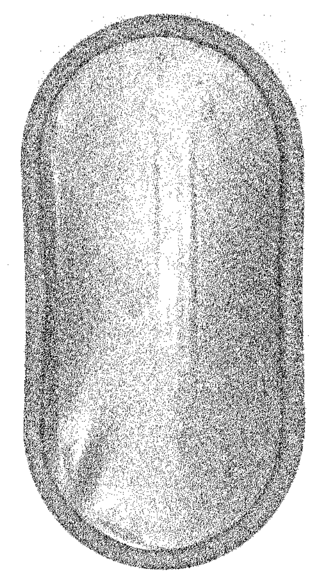

FIG 1. *The Quick Dam, showing the rolled border that supports the dam intraorally*

fingers of the other hand, the dam was folded forward on itself to form a "C" shape, and inserted in the mouth for try-in. Teeth to be isolated were marked, the dam removed, and holes punched as marked.

S S White (Holmdel, NJ 07733), ESPE/Premier (Norristown, PA 19404), or other dam punches of similar design are necessary to punch holes. The Ivory punch with a constant centering pin will not fit easily over the flex ring.

The Quick Dam was applied, isolating teeth as desired. Dental floss was used to place the material between adjacent teeth. The dam material was inverted in the usual manner. Clamps and/or dental floss ligatures were applied as needed to assist in keeping the material inverted around the gum line of the tooth/teeth being isolated (Figs 2 & 3). When properly fitted, the outer flex ring fits snugly against the buccal oral mucosa laterally and the fold of the Quick Dam covers the oropharynx posteriorly and acts as a curtain to prevent debris from passing to the throat.

Several criteria were assessed. Of primary concern was the comfort experienced by the patient when the isolation device was used as compared to the conventional rubber dam. The effectiveness of the isolation and ease of use experienced by the dentist and auxiliary (user) were also of concern. Two evaluation forms were used: one for the patient and one for the user.

Employing a scale of 1-5 (1 = best, 5 = worst), 23 patients evaluated the following criteria: comfort of dam, ease of installation, ease of breathing, and effective seal of throat from debris. Patients were also asked to evaluate their experience with the new isolator as compared to previous experiences with rubber dams.

Employing a scale of 1-3 (1 = best, 3 = worst), 24 dental operators evaluated the following criteria: auxiliary acceptance, ease of installation, working field control, and isolation effectiveness without a clamp. Also rated was an overall assessment of the new dam as compared to conventional dams requiring a "yes/no" answer. All forms included a section for comments.

Results

The results, as recorded on the patient's questionnaire, were favorable regarding the overall use of the rubber dam. Patients rated

FIG 2. *The Quick Dam in place. It is seen that the border of the dam makes a seal with the buccal mucosa.*

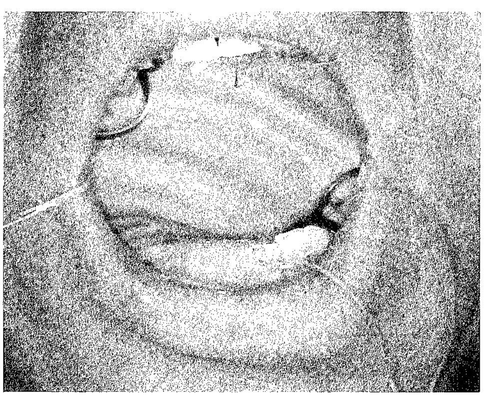

FIG 3. *Utilization of the Quick Dam to isolate teeth on opposite arches*

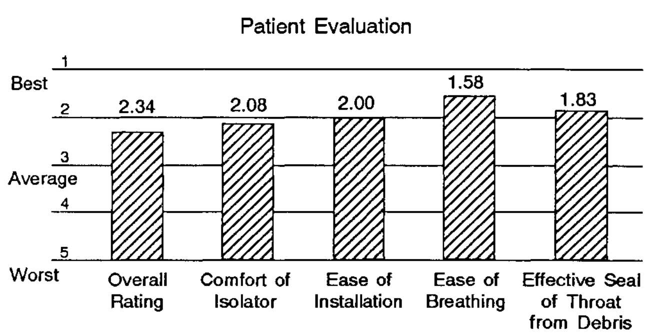

FIG 4. *Patient evaluation showed the patients experienced excellent ease of breathing and effective seal of throat from debris. The overall rating by the patients was high.*

the comfort of the new dam at 2.08 (Fig 4). This indicates a good patient acceptance and improved comfort of this dam as compared with conventional rubber dams. Eleven (48%) of the patients rated their experience excellent, eight (35%) rated the new dam adequate and four (17%) rated it poor (Fig 5).

Of the patients who rated the dam poorly, one did not like the thickness of the dam, another experienced a gagging reflex, and a third said it was so uncomfortable after 10 minutes it had to be removed. Conventional dams were successfully used with these patients. Other criteria such as ease of installation (2.00), ease of breathing (1.58), and sealing throat from debris (1.83) were rated well for the Quick Dam.

Seventeen of the 24 users rated the Quick Dam as an improvement over conventional dams; one rated it as equal and six gave it a poor rating. The overall evaluation by the user, based on experience relative to the use of conventional rubber dams, was very favorable, with 75% of the operators citing positive responses using the system (Fig 6).

The following results were obtained for the users: auxiliary acceptance (1.50), ease of installation (1.35), working field control (1.61), isolation effectiveness (1.76), soft tissue control (1.74), and effectiveness without a clamp

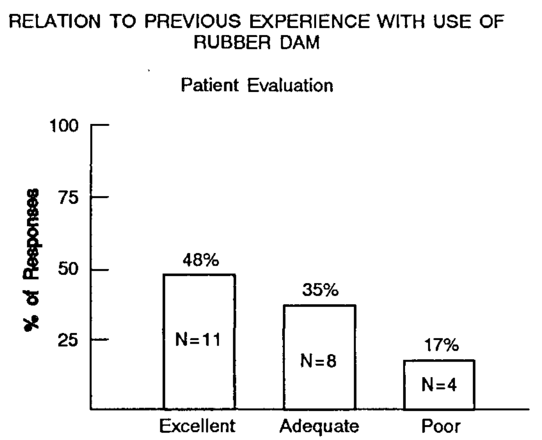

FIG 5. *The majority of patients rated their experience with this dam in relation to previous experience with rubber dams as positive.*

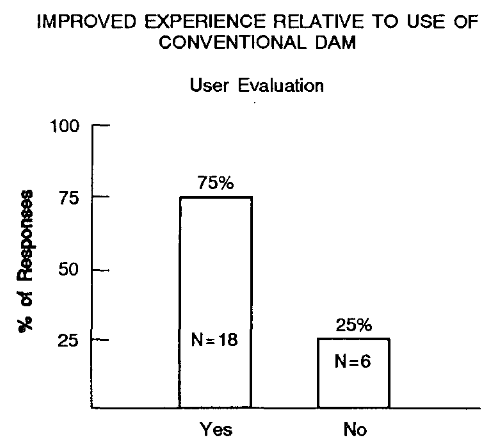

FIG 6. *This shows that the majority of operators feel the use of this dam to be an improvement relative to their experience with conventional dams.*

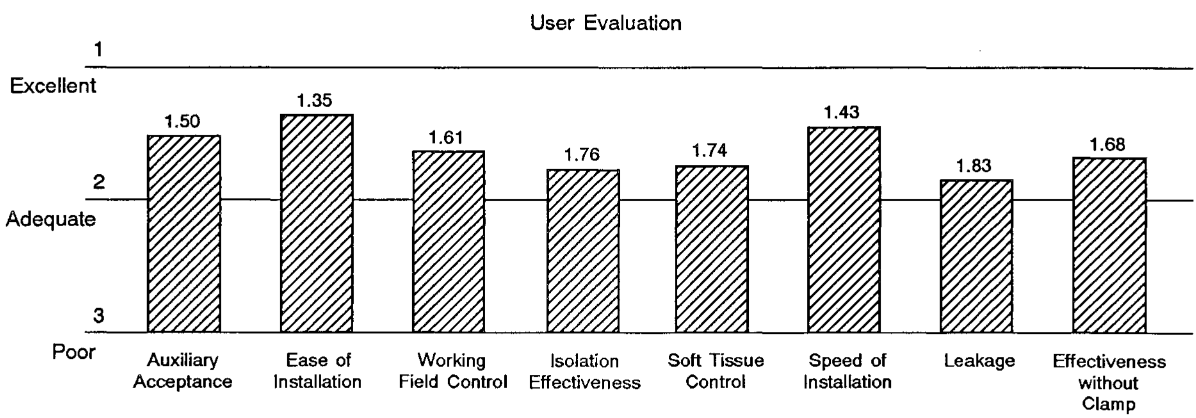

FIG 7. *The operators valued ease and speed of installation with the highest grade, and most criteria were evaluated well.*

(1.68) (Fig 7).

Most of the restorations completed were on anterior teeth, although there were several simple occlusal restorations completed satisfactorily on molars. The most often cited problem was inadequate coverage of the parotid duct area to treat posterior teeth in a moisture-free environment. In order to rectify this problem the company is experimenting with a supplemental device to cover this area and so improve the use of this dam for work on posterior teeth. Other negative comments included size of the dam, and one user said the dam had a tendency to ride up occlusally. Other users rated the dam excellent in all categories. At least eight of the users rated the dam with a one in six or more of the eight categories evaluated.

Conclusions

The study concluded that there was significant improvement in user acceptance and patient comfort with the new isolation device when compared to the conventional rubber dam. Also, from the comments of the users, it was suggested that it is ideal for use with anterior teeth, but saliva control was not as positive for posterior teeth.

It is noted that this device is size-sensitive. The flex ring should fit snugly against the inner cheek wall and conform to the contour, and it is this snug fit that is the basis for a proper seal and a consequent dry field. Too large a unit can cause discomfort to the patient, as the spring action in the flex ring retracts the soft tissue. The only size unit available for the study was the medium size, and some problems encountered may have been related to size.

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Dentin Bonding Agents and the Smear Layer

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Summary

The morphology and treatment of the smear layer are discussed. Also included are a review of dentin bonding agent classification and chemistry, and a summary of recent bond strength research results. Finally, the current status of dentin bonding agents is discussed.

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Introduction

A recent development in the field of dental materials that adhere to tooth structure is the introduction of dentin bonding agents. Theoretically, these materials allow a more conservative approach to cavity preparation, since the reliance on traditional retentive features is lessened, making it possible to remove far less sound tooth structure. The purposes of this paper are to 1) present some background on the development of dentin bonding agents, 2) discuss the classification and chemistry of dentin bonding agents, as well as the various smear layer treatments recommended for their use, and 3) summarize recent bond strength results.

The enamel acid-etch technique,introduced by Buonocore (1955) over 35 years ago, stimulated the search for materials that could adhere to enamel and/or dentin. The acid-etch technique provided improved marginal adaptation and retention through micromechanical means, making clear the potential benefits of an intimate adaptation of restorative materials to tooth structure.

Early efforts to develop restorative systems that would adhere chemically to dentin produced materials with low bond strengths and poor clinical durability (Buonocore, Wileman & Brudevold, 1956). Although these early materials were never released for clinical use, they demonstrated that chemically adhesive systems were possible.

As the interest in chemical adhesion has grown, researchers have attempted to define those factors that are critical to the development of high bond strengths to prepared dentin. Much effort has been devoted to determining the morphology and composition of the prepared dentinal surface. The relatively amorphous coating layer of debris that results from the rotary instrumentation of dentin has been termed the smear layer (Eick & others, 1970).

The Smear Layer

The smear layer, when observed under a scanning electron microscope, has a rough, smeared appearance, with obliterated tubule orifices. It contains, in varying amounts, blood, saliva, bacteria, enamel, and dentin particles (Brännström & Johnson, 1974). The morphology and character of the smear layer are determined to a great degree by the instrument used to generate it (Gwinnett, 1984). For example, a bur in a high-speed handpiece produces a coarser texture than does the same bur in a conventional-speed handpiece.

The thickness of the smear layer also varies as a function of whether the dentin is dry or wet during rotary instrumentation (Pashley, 1984). In addition, its composition is influenced by the area in dentin in which it is generated, because of differing organic to inorganic component ratios (Causton, 1984) and percentage area of dentinal tubuli (Suzuki & Finger, 1988). All of these variables can affect the integrity, morphology, and composition of the smear layer, and perhaps its potential to bond with a dentin bonding agent.

There are two divergent opinions regarding smear layer treatment. Some believe that the smear layer acts as an effective, natural cavity liner that seals dentinal tubules and reduces permeability, making the smear layer a clinical asset (Douglas, 1989). Others argue that the smear layer interferes with adhesion of restorative materials, serving as a focus for bacteria and bacterial toxins, and that it therefore should be removed (Bowen, 1978). One study reported that the smear layer, which was firmly attached to the dentin initially, became loose and largely was replaced by bacteria and fluid within a few weeks (Brännström & Nyborg, 1973).

Bowen and his colleagues (Bowen, Cobb & Rapson, 1982) have attempted to replace the smear layer with a layer of crystals. Their use of metallic salts of oxalate as a fixative agent (acidic mordant) both acid-etches the dentin and occludes the tubules with a crystalline material.

Pashley and others (1989) found the smear layer to be effective in restricting dentin permeability. In addition, they found that shear bond strengths of Scotchbond (3M Dental Products, St Paul, MN 55144) to dentin, with the smear layer intact, were higher than to dentin with the smear layer removed. Following smear layer removal with 6% citric acid, there was a large increase in dentin permeability and a large decrease in bond strength for both occlusal and buccal dentin. Treatment of dentin with the oxalate solutions completely reversed the effects of dentin acid-etching; dentin permeability fell back to values that were not statistically different from those with the smear layer present. Low permeability was also associated with a statistically significant increase in shear bond strength, indicating that crystals of calcium oxalate may have provided some chemical retention with restorative materials.

Smear Layer Treatment and Dentin Bonding Agents

Dentin bonding agents are the group of intermediary materials used to attach composite resin to dentin. To chemically attach a restorative system to tooth structure, one of several options must be considered for the smear layer. For the dentin bonding agents presently

Dentin Bonding Agents

Classification	Manufacturer	Treatment of Smear Layer	Treatment Agent
Second Generation			
Prisma	Caulk/Dentsply	None	None
Scotchbond	3M	None	None
Third Generation			
Gluma	Columbus Dental	Remove	EDTA
Scotchbond 2	3M	Dissolve	Maleic acid HEMA
Tenure	Den-Mat Corp	Remove/ Replace	Nitric acid, Phosphoric acid, Aluminum oxalate
Unclassified*			
Mirage	Chameleon Dental	Dissolve	Nitric acid, NPG-GMA
Prisma 2	Caulk/Dentsply	Modify	HEMA, PENTA
XR Bond	Kerr/Sybron	Modify	Ethyl alcohol, Dimethyl-acrylate, Phosphate ester, Camphoquinone
All-Bond	BISCO	Modify	Succinic acid-HEMA

*Unclassified: Dentin bonding agents in this grouping have not yet been formally classified, but all require dissolution or modification of the smear layer.

available (see table), the smear layer is managed in one of five ways.

The first treatment is no treatment at all. The smear layer is left in place, without modification, and the dentin bonding agent is applied directly to it. Both Scotchbond (3M Dental Products) and Prisma (The L D Caulk Div, Dentsply International, Milford, DE 19963) function through an intact smear layer.

The second treatment for the smear layer is dissolution. This dissolved smear layer plays a part in the chemical attachment of the dentin bonding agent to dentin. Both Scotchbond 2 (3M Dental Products) and Mirage Bond (Chameleon Dental, Kansas City, KA 66101) call for dissolution of the smear layer.

The third method of treatment is smear layer removal. Gluma (Columbus Dental, St Louis, MO 63188) requires smear layer removal and develops chemical attachment directly to intact dentin.

The fourth method of smear layer treatment involves its modification. This process theoretically improves the attachment of the smear layer to dentin. In addition, modification is thought to allow for better interaction of the dentin bonding agent with the smear layer. Prisma 2, Prisma 3 (L D Caulk), XR Bond (Kerr/Sybron, Romulus, MI 48174) and All-Bond (BISCO, Inc, Downers Grove, IL 60515) all call for modification of the smear layer.

The fifth means of smear layer treatment involves its removal and replacement with another mediating agent. The only dentin bonding agent of this type presently available (Tenure, Den-Mat Corp, Santa Maria, CA 93456) replaces the smear layer with oxalate crystals, which are deposited in the dentinal tubules.

Dentin Bonding Agent Classification and Chemistry

The most commonly accepted classification system for dentin bonding agents divides them into three categories, or generations (Setcos, 1988; Retief, 1989). This classification system is based on chemical formulation as well as smear layer treatment.

Among the first-generation dentin bonding agents were glycerophosphoric acid dimethacrylate, cyanoacrylates, and the chemical addition product of N-phenyl glycine and glycidylmethacrylate (NPG-GMA) (Retief & others, 1988). No commerical products are currently available from this generation. Intra-oral hydrolysis of the glycerophosphoric acid dimethacrylate, polymerization problems of the cyanoacrylate, and the instability of NPG-GMA in solution precluded their use in clinical dentistry.

Second-generation dentin bonding agents, requiring the presence of the smear layer, are mainly phosphate ester systems and polyurethanes. The phosphate ester-based dentin bonding agents rely on the chemical reaction between phosphate groups and calcium. The urethane/isocyanate forms covalent bonds with hydroxyl groups in both the organic and inorganic phases of dentin.

Third-generation dentin bonding agents require removal or dissolution of the smear layer prior to dentin bonding agent application. In the Tenure system, the smear layer is removed and replaced by aluminum oxalate crystals. HEMA and glutaraldehyde in Gluma bond to the organic phase of dentin. Scotchbond 2 contains BIS-GMA, HEMA, maleic acid and a photoinitiator.

Several recently introduced dentin bonding agents remain unclassified at this time (see table). Although none of these newer systems remove the smear layer, they all require its dissolution or modification.

Laboratory and Clinical Performance

Numerous laboratory studies have tested the bond strength of dentin bonding agents to dentin (Bowen & others, 1982; Cooley & Dodge, 1989; Mitchem, Terkla & Gronas, 1988; Munksgaard & Asmussen, 1984; Retief & others, 1990). Most in vitro studies have attempted to determine bond strengths by means of tensile or shear testing on a prepared flat dentin surface. Results have generally indicated higher bond strengths for dentin bonding agents that require smear layer removal or dissolution (Barkmeier & Cooley, 1989; Davis & others, 1989; Eliades, Caputo & Vougiouklakis, 1985; Prati & others, 1990; Retief & others, 1988; Wendt, Jebeles & Leinfelder, 1990; Zidan & AlJabab, 1990). A notable exception has been the variable results reported for Gluma. Gluma is a third-generation dentin bonding agent based on HEMA and glutaraldehye, which bond to the organic phase of dentin. One explanation for the differing results for this material may relate to its instability, as glutaraldehyde is a reactive compound that polymerizes over time (Cooley & Dodge, 1989).

A recent study (Yu & others, 1991a) reported the bond strength of second- and third-generation dentin bonding agent systems using a three-dimensional, class 5 cavity preparation. Results indicated highest bond strengths for two third-generation systems (Tenure and Scotchbond 2). Both require either dissolution (Scotchbond 2) or removal (Tenure) of the smear layer.

A related study (Yu & others, 1990) that evaluated the surface morphology of treated dentin indicated that the bonding surface for dentin bonding agents that require the smear layer is the smear layer itself, rather than underlying dentin. Further research examining the restoration interfaces in smear layer-mediated dentin bonding agents implicates the attachment of the smear layer to the underlying intact dentin as the weak link in these systems (Yu & others, 1991b). Such restorative systems exhibited gaps along the smear layer/dentin interface, suggesting that the stresses developed within the restorative materials exceed the adhesive strength of the smear layer to dentin.

Clinically, second-generation dentin bonding agents have exhibited variable results, with one-year failure rates ranging from 8 to 100% (Council on Dental Materials, Instruments, and Equipment, 1987). Third-generation and newer dentin bonding agents are still undergoing clinical trials. Jordan and others (1989) reported a clinical study using Tenure and Scotchbond 2 to restore cervical erosions without cavity preparations. Both systems demonstrated a retention rate of 98% at the end of a six-month clinical evaluation period.

Tenure is a chemically cured liquid system that can be used in a variety of restorative situations, whereas Scotchbond 2 is a light-activated resin system.

Currently only Tenure and Scotchbond 2 have been approved by the American Dental Association. In order to receive provisional acceptance, a dentin bonding agent must achieve a six-month retention rate of at least

95% in two independent clinical evaluations. For full acceptance, restorations must demonstrate a three-year retention rate of at least 80%.

Conclusions

The development of dentin bonding agents has made possible the chemical attachment of composite resin restorations to tooth structure. Second-generation dentin bonding agents make use of the smear layer, and depend on its presence to achieve chemical bonding. These materials develop rather modest bond strengths that appear to diminish significantly over time. While these dentin bonding agents are still available, newer agents that require alteration or complete removal of the smear layer generally produce higher bond strengths of greater durability. Some third-generation dentin bonding agents have developed bond strengths to dentin comparable to those achieved to acid-etched enamel surfaces.

Review of the literature indicates that third-generation dentin bonding agents, in general, produce the highest bond strengths to dentin. In laboratory studies both Tenure and Scotchbond 2 have consistently outperformed other dentin bonding agents. These in vitro studies provide some measure of the potential clinical performance of dentin bonding agents. However, results of standard laboratory testing may not correlate well with clinical results. Mitchem and others (1988), for example, found that dentin bonding agent bond strength was adversely affected when dentin was maintained under physiological conditions.

Although both Tenure and Scotchbond 2 have received approval from the American Dental Association, and can be used under composite resin restorations, further clinical trials are needed to determine the long-term performance of dentin bonding agents.

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DEPARTMENTS

Press Digest

The editor wishes to thank the second-year Comprehensive Dentistry Residents at the Naval Dental School, National Naval Dental Center, Bethesda, Maryland for their assistance in the preparation of the following abstracts.

At-home bleaching system: effects on enamel and cementum. *Scherer, W, Cooper, H, Ziegler, B & Vijayaraghavan, T V (1991) *Journal of Esthetic Dentistry* 3 54-56.

(*New York University College of Dentistry, Advanced Education Program in General Dentistry, 345 East 24th Street, New York, NY 10010)

This in vitro study investigated the effects of an at-home bleaching gel on enamel and cementum surface morphology. Fifteen extracted teeth were divided into five groups as follows: three groups were bleached with an at-home system containing 10% carbamide peroxide for 5, 15, and 30 days, one group was only exposed to 37% phosphoric acid for 20 seconds, while the last group was used as a control. The teeth exposed to vital bleaching were brushed for 20 seconds three times per day. After 5, 15, and 30 days each group was evaluated using electron microscopy. The results showed that only the acid-etched group exhibited etching patterns, while brushing with a vital bleaching system for 30 days had no effect on surface morphology. A one- or two-shade change was also noted in the group of teeth bleached for 30 days. This study supports other reports that indicate tooth surface morphology is not affected by vital bleaching agents.

Effect of endodontic access preparation on resistance to crown-root fracture. Howe, C A & McKendry, D J* (1990) *Journal of the American Dental Association* 121 712-715

(*Department of Endodontics, The State University of New York at Buffalo, 240 Squire Hall, Buffalo, NY 14214)

An in vitro study investigating the resistance to fracture of mandibular molars when the tooth was 1) intact; 2) prepared for endodontic access only; 3) prepared for a conservative MOD amalgam; 4) prepared with both a MOD amalgam and endodontic access. All prepared teeth were weaker than the intact tooth. The weakest tooth had both endodontic access and a MOD preparation. There was no significant difference between endodontic access only and a MOD preparation.

Effects of fluoride and chlorhexidine on the microflora of dental root surfaces and progression of root-surface caries. Schaeken, M J M, *Keltjens, H M A M & Van Der Hoeven, J S (1991) *Journal of Dental Research* 70 150-153.

(*University of Nijmegen, Institute of Preventive and Community Dentistry and Department of Oral Function and Prosthetic Dentistry, P O Box 9101, 6500 HB Nijmegen, The Netherlands)

This clinical research report studied the effects of locally applied fluoride and chlorhexidine varnishes on plaque microflora of dental root surfaces and progression of root surface caries in patients surgically treated for advanced periodontal disease. The patients were divided into three groups, provided with basic preventive care, and placed on a maintenance program with three-month recalls. The fluoride and chlorhexidine groups had root surfaces treated at three-month intervals with fluoride and chlorhexidine varnishes respectively. The control group received only maintenance care. Plaque samples from sound and carious root surfaces were taken at baseline and quarterly. Root surface lesions along with their texture, depth, and color were recorded at baseline and at one year. *Mutans streptococcus* was decreased significantly by the chlorhexidine but not the fluoride. *Actinomyces viscosus/naeslundii* increased but not significantly with both fluoride and chlorhexidine. Both fluoride and chlorhexidine groups had significantly lower incidences of decayed and filled surfaces than the control group. Significantly more lesions were hardened with chlorhexidine varnish. Color was not found to be a reliable indicator of active versus arrested caries. The study demonstrated that both fluoride and chlorhexidine varnishes have the potential to reduce the incidence and progression of root surface caries, especially on approximal surfaces that are more difficult to clean.

Using composite resin as a posterior restorative material. *Leinfelder, K F (1991) *Journal of the American Dental Association* 122 65-70.

(*The University of Alabama School of Dentistry, Birmingham, AL 35294)

This paper discusses the conditions under which posterior composite resin can be used successfully for approximal-occlusal restorations. It also provides guidelines for proper tooth selection and cavity preparation, suitable materials, appropriate techniques, and long-term maintenance of the restored tooth. This has been a major area of interest to the restorative dentist, especially because of the recent controversy over the use of amalgam as a restorative material. The author stresses that the decision to employ posterior composite resins should be based upon independently conducted studies and well-documented clinical data, not on physical and mechanical properties. The procedure is admittedly technique-sensitive; however, by utilizing exacting but uncomplicated methods, the placement of improved posterior composite resins can result in restorations nearly as wear-resistant as amalgam.

Prosthetic implants: risk of infection from transient dental bacteremias. *Little, J W (1991) *Compendium of Continuing Education in Dentistry* 12 160-168.

(*The University of Minnesota School of Dentistry, Minneapolis, MN 55455)

The risk of infection from prosthetic devices secondary to transient dental bacteremias and recommendations for dental management are examined in this paper. National guidelines are provided by the American Heart Association for treating dental patients with prosthetic heart valves. No such guidelines are given from any national medical organization regarding the need for prophylaxis in patients with other types of implanted prosthetic devices. The prosthetic devices that are reviewed include prosthetic heart valves, vascular grafts, transvenous pacemakers, cerebrospinal fluid shunts, prosthetic joints, penile implants, intraocular lenses, breast implants, and intravascular access devices. The most common cause of infection with all devices was found to be wound contamination at the time of insertion. In rare cases, hematogenous spread of organisms from distant sites of acute infection can infect prosthetic devices.

Modification of the resistance form of amalgam coronal-radicular restorations. Kane, J J & *Burgess, J O (1991) *Journal of Prosthetic Dentistry* 65 470-474.

(*Wilford Hall, USAF Medical Center, Lackland AFB, San Antonio, TX 78284)

The resistance form of three designs of amalgam coronal-radicular restorations were compared. The occlusal surfaces of all specimens were reduced until a 4 mm pulp chamber height remained; this served as the control group. A peripheral shelf, 1. 4 mm wide and 2 mm deep, was added to a second group. Four TMS Minum pins were placed at 45° to the long axis of the tooth into the walls of the pulp chamber of a third group. After restoration with amalgam, an Instron Testing Machine directed a 45° force until failure occurred. The peripheral shelf did not improve fracture resistance, while the force required for fracture of the four pins was significantly higher. The authors caution that pins should only be used when sufficient dentin remains.

Book Reviews

EXPERT THIRD MOLAR EXTRACTIONS

Soichiro Asanami, Yasunori Kasazaki

Published by Quintessence Publishing Company, Chicago, 1990.109 pages, 330 color photographs and illustrations. $36.00.

This book is a hardbound manual that describes techniques for extracting maxillary and mandibular third molars. It has 30 chapters without an index or bibliography. Mandibular and maxillary third molars are classified in chapters 2 and 25 respectively. The subsequent chapters, appropriately titled using the tooth classifications in chapters 2 and 25, each describe a technique for removing a single class of impacted third molar.

Each chapter begins with a thumbnail summary of the extraction. For example, the authors predict that the mesial-inclined mandibular third molar in chapter 4 that is moderately covered by bone will be a difficult extraction requiring a mucoperiosteal flap, removal of bone, sectioning of the tooth, and 40-60 minutes to extract, while the mesial-inclined mandibular third molar in chapter 5 that is minimally covered by bone will be an easy extraction requiring a mucoperiosteal flap without removal of bone or sectioning of the tooth and approximately 15 minutes to extract. These highlighted summaries make it simple for the dentist to predict the difficulty of the extraction and schedule adequate time for removing the tooth. The dentist might also decide not to remove the tooth, referring the patient to a specialist if the extraction is too difficult.

The illustrations in each chapter are outstanding. The techniques are described in detail and illustrated with high-quality color photographs complemented with excellent diagrams. There is minimal text, but the simple step-by-step instructions are easy to follow and are clearly illustrated with diagrams and photographs. If the instructions are followed, the dentist will be able to remove even extremely difficult third molars. Because the techniques are described with minimal text, the steps required to extract a third molar can easily be reviewed in a few minutes before extracting a tooth.

In spite of the excellent descriptions and illustrations, the book has some flaws. The authors recommend extracting right third molars from the patient's right and left third molars from the patient's left. However, most dental operatories are not designed to let the dentist treat patients from both the right and left sides of the dental chair. The authors recommend removing buccal bone with a "chisel;" however, patients who receive local anesthesia alone without sedation do not usually tolerate having bone, especially on the mandible, removed with a chisel. Finally, the authors recommend using a water-air turbine bur to section teeth and suggest if air emphysema occurs the edema can be reduced "by compressing the area buccal to the third molar ..." Because subcutaneous air emphysema can spread oral bacteria into the soft tissues as well as compromise vital functions, use of water-air turbine drills for the removal of third molars cannot be recommended. Two recent case reports in Volume 120 (1990) of the *Journal of the American Dental Association* (Buckley, M J, Turvey, T A, Schumann, S P & Grimson, B S: Orbital emphysema causing visual loss after dental extraction, pages 421-424, and Reznick, J B & Ardary, W C: Cervicofacial subcutaneous air emphysema after dental extraction, pages 417-419) confirm that water-air turbine drills should not be used when removing third molars.

The few flaws in the book, however, do not detract from the excellent descriptions of the principles that pertain to the extraction of third molars. The dentist should ignore the recommendations to use a chisel and water-air turbine handpiece and use a surgical handpiece that is autoclavable and that does not spray air and water into the surgical site when removing bone and sectioning teeth.

Dentists and dental students who want to learn how to remove third molars will find this book a valuable reference. They will also find it a valuable book to have in their office libraries.

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ANTIBIOTIC/ANTIMICROBIAL USE IN DENTAL PRACTICE

Michael Newman, Kenneth Kornman, Editors
Published by Quintessence Publishing Co, Inc, Chicago, 1990. 240 pages, 16 illustrations. $30.00.

The text was edited by Dr Newman and Dr Kornman, both from the Department of Periodontics at the University of California, Los Angeles. There are 17 contributors, with approximately half of the authors from that university. None of the authors are pharmacologists, according to the credentials, and there is an apparently significant gathering of authors from the Department of Periodontics at the University of California, Los Angeles.

The editors' introduction to the text is focused mostly on the new contributions for this new version of another text, but there is little information about the authors' intent and scope of the book and the particular reader to whom the text is directed. One comment indicates that this is primarily directed to the private practitioner, both in general dentistry as well as the various specialities in dentistry. The content of the text is broken down into five basic parts: "General Principles," "Drugs of Choice," "Adverse Reactions," "Clinical Application," and "Special Considerations."

The text is reasonably well written. The majority of the books on pharmacology and pharmacological therapeutics do not cover the depth that this book does in terms of the pragmatics of therapeutics. It is written in a relatively concise manner without excessive redundancy or major deletions. The book is a useful guide for practicing dentists and could be used in the academic arena for dental students as a guide to antimicrobial pharmacotherapeutics.

The overall organization of the book is quite good, which is no small task, considering the large number of contributors. Each of the 20 chapters is followed by a list of references, the majority of which are within the last decade. The book provides insight into the use of antimicrobial agents in the practice of particular disciplines of dentistry and is adequate for the general practitioner. A specialist in each of these areas would require more depth than is provided in this text, particularly in the clinical application section.

There are a few aspects of the text which need to be improved, as follows: There is an excessive focus on antimicrobial therapy for infections associated with periodontal disease and there is inadequate coverage of antiviral and antifungal agents; the section on topical antimicrobial agents is excessive; the section on chemotherapeutic agents in restorative dentistry should be deleted since there is little or nothing of value covered; the authors have completely overlooked antimicrobial agents of mucosal infections; lastly, the outlined protocol for prophylactic antibiotics to prevent endocarditis does not cover the current American Heart Association recommendations.

In summary, this is a text that focuses on the use of antimicrobial agents in the practice of dentistry, with the book divided into sections that focus specifically on the use of these agents within each specialty or discipline of dentistry. The book is unique from the standpoint of allowing the clinician to access specific topics to review based on the anatomical region or discipline of dentistry in which the infection occurs. While I feel the section on periodontics and periodontal disease may be excessive, the topics are adequately covered, with the exception of the obvious hiatus in the area of mucosal infections and the pharmacological therapeutic management of bacterial fungal and viral infections.

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MODERN CONCEPTS IN THE DIAGNOSIS AND TREATMENT OF FISSURE CARIES

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Published by Quintessence Publishing Co, Inc, Baden-Baden, Germany, 1991.80 pages, 93 illustrations. $40.00.

The authors' stated purpose is "to give an illustrated guide to the management of fissure caries, designed for the busy practitioner who wishes to keep abreast of modern techniques, but who may not have the time available to read widely." This book meet the authors' stated objective of providing a well-illustrated overview of the subject of pit and fissure sealants. The discussions of materials are constrained by the limited space and scope of the work and as with all books, the data are not quite current.

The 93 figures, most of which are color photographs, demonstrate the techniques or principles the authors are trying to illustrate and mesh well with the written text. The work is indexed on both topic areas and products discussed, which has usefulness as discussed below. The book also contains a limited reference section that is divided by chapter and a two-page summary of the authors' "rules" for fissure management. This provides a quick review of their salient points.

The book is divided into three parts along logical lines. Part 1 reviews the early fissure lesion, the materials for management, and the necessity for preparation extension into uninvolved portions of a fissure. Part 2 is devoted to examination techniques and treatment options based on diagnostic findings. Part 3 reviews each technique in greater detail. This organization allows the reader to focus on a particular clinical problem, determine the acceptable technique(s), and then review that specific technique, which is a very efficient way to meet the book's stated goals.

I recommend this book for addition to your dental library if you are not a researcher or have not reviewed the topic of pit and fissure sealants recently. It provides a nice overview of the topic without becoming bogged down with details.

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A LABORATORY MANUAL FOR GENERAL AND ORAL PATHOLOGY

S Eda, H Fukuyama, K Kitamura, N Nagai, N Utsumi, T Yamamura, S Yoshiki

Published by Quintessence Publishing Co, Inc, Chicago, 1991. 257 pages, 445 color illustrations, $90.00.

This book is a laboratory manual that combines certain aspects of general and oral pathology, with more emphasis on the latter. It was written by 12 oral and general pathologists from seven different schools in Japan. The "General Pathology" section is divided into circulatory disturbances, regressive changes, progressive changes, inflammation, tumors, and a chapter referred to as "Others," where diseases such as liver cirrhosis are covered. The "Oral Pathology" section covers numerous subjects such as malformation of teeth, progressive changes of dentin and cementum, healing of extraction wounds, injuries of teeth, dental caries, diseases of dental pulp, diseases of tongue and oral mucosa, to name a few. This book cites no references. It presents color photomicrographs and occasional clinical pictures, radiographs, and pictures of the gross specimens.

The main objectives were to combine general and oral pathology in one book and perhaps to create a laboratory manual that can be used by more than the seven Japanese dental schools. Although the objectives are excellent and well considered, the results are not satisfactory. The authors use unusual classifications and categories of diseases: for example, regressive and progressive diseases. Although they define regressive changes as "a result of decline or loss of function in cells," they include diseases such as leukoplakia and pigmented nevi in this chapter. The book is replete with these types of categorizations that are rarely used, especially in the USA. In order for the authors to target a wider readership, it is recommended that more universally accepted classifications and terminology be applied. They should delete terms such as keratin degeneration, epulis, sialoma, synsialoma, fibro-osteomatosma, etc.

This book lacks organization and consistency. This is evident in practically every chapter. As an example, radiographs are included under "macroscopic findings" on pages 119 and 120, in the introduction on page 135, and as a separate category on page 211.

Very little emphasis is placed on oral mucosal lesions such as squamous cell carcinomas. There is no mention of smoker's keratosis. The etiologies of leukoplakia on page 183 cover unusual factors such as sex hormones, but do not include more established etiologic agents such as tobacco and alcohol. Another area of deficiency is the lack of information on AIDS and AIDS-related oral and systemic diseases such as oral hairy leukoplakia, Kaposi's sarcoma, and pneumocystis carinii pneumonia.

In summary, the concept of combining oral and general pathology is unique and commendable but difficult to accomplish. In the process of combining the two, numerous diseases were not adequately discussed. Lack of state-of-the-art knowledge was evident, as were obvious spelling and grammatical errors. These reviewers are unable to recommend this book without extensive editing, proper classification and terminology of diseases, and recent and classical references.

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REPLICATION OF ANTERIOR TEETH IN THE FOUR SEASONS OF LIFE

Klaus Müterthies

Published by Quintessence Publishing Co, Inc, Chicago, 1991. 90 pages, 261 illustrations, $62.00.

Mr Müterthies again shows the dental technician his techniques for anterior esthetics with ceramometal restorations, along with his previous atlas dealing with techniques for mandibular anterior esthetics. This current atlas also deals with anterior esthetics but focuses on age-related changes of natural tooth structure, which should be incorporated into the fabrication of the prosthesis. This will allow for a restoration that will blend in with the patient's age.

The text is concise in explaining the age-related changes in terms of shape, surface structure, and characterizations. Little is held back in the demonstration of the build-up technique for each "season," from initial metal preparation to the final glaze, and is presented with sequential photographs that allow for the technician first trying these techniques to follow along quite easily. This is different from many other ceramic texts that many times fail to adequately show the readers how to obtain the spectacular results shown.

This text is highly recommended, as it will show those interested what makes a tooth fit into a certain season and how to implement that look into a ceramic restoration.

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References

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