

1981

An in vitro comparison of a light-cured composite resin and self-polymerizing resin in conventional and modified cavities with and without the use of an intermediary bonding agent

<https://hdl.handle.net/2144/44134>

Downloaded from DSpace Repository, DSpace Institution's institutional repository

609-632
20 JUL
1981
1.0

BOSTON UNIVERSITY
HENRY M. GOLDMAN
SCHOOL OF GRADUATE DENTISTRY

THESIS

AN IN VITRO COMPARISON OF A LIGHT-CURED
COMPOSITE RESIN AND SELF-POLYMERIZING
RESINS IN CONVENTIONAL AND MODIFIED
CAVITIES WITH AND WITHOUT THE USE OF
AN INTERMEDIARY BONDING AGENT

by

ALI ASGHAR ALAVI, D.M.D.

Shiraz University
School of Dental Medicine

Submitted in Partial Fulfillment of the
Requirements of

Master of Science in Operative Dentistry

(specialty)

1981

92,105

Boston University

Copyright and Digitization Notice

Copyright of this work is held by the author.

This work is protected against unauthorized copying under Title 17, United States code.

This reproduction is made available for personal use, and is not for distribution.

The image quality of this digital reproduction depends on the quality of the print original. Signatures and personal information, if present, have been redacted.

Thesis
WU 350
A324i
1981
C.1

BOSTON UNIVERSITY
HENRY M. GOLDMAN
SCHOOL OF GRADUATE DENTISTRY

THESIS
AN IN VITRO COMPARISON OF A LIGHT-CURED
COMPOSITE RESIN AND SELF-POLYMERIZING
RESINS IN CONVENTIONAL AND MODIFIED
CAVITIES WITH AND WITHOUT THE USE OF
AN INTERMEDIARY BONDING AGENT

by

ALI ASGHAR ALAVI, D.M.D.

Shiraz University
School of Dental Medicine

Submitted in Partial Fulfillment of the
Requirements of

Master of Science in Operative Dentistry

(operatory)

1981

201.00

ABSTRACT

An important advance in restorative dentistry in recent years has been the indication that microleakage can be minimized around a composite resin with the use of acid etching and placement of an intermediary bonding agent on the walls of cavity preparations. Elimination or reduction of microleakage would result in a decrease in sensitivity, discoloration, and recurrent caries. Investigations have shown that microleakage is significantly reduced or eliminated in restorations where the enamel was etched and a layer of unfilled resin was placed before placement of the restorative material.

Some investigators recommended modification of classic preparation design for composite resins, such as butt joint/overlayed, beveled joint and curved bevel joint.

This study evaluated the marginal leakage of three commercially available composite resins in restorations prepared with different cavo surface design and modes of treatment.

Eighty class V cavities were prepared in extracted human teeth. The teeth were stored in 10% formalin following extraction and divided into ten groups. One group was used as a control group. Conventional and modified class V preparations were restored with Silar, Profile and Prismafil. Some of the cavities were acid-etched and a bonding agent was applied.

After thermal cycling was conducted, using a methylene blue dye, the specimens were sectioned and examined for microleakage with a stereo dissecting microscope.

The results show that for all three composite systems when used with a beveled cavo surface there was less microleakage. It is evident that the best seal at the enamel-composite interface was achieved by means of a cavo surface-bevel and acid-etch in conjunction with the application of an intermediary bonding agent.

READERS APPROVAL

First Reader

Cornelis H. Pameijer, D.M.D., M.Sc.D., D.Sc.
Professor and Chairman Department of Biomaterial



Date

Nov 5, 1981

Signature

Second Reader

Lloyd B. Chaisson, D.D.S.
Professor and Chairmand Department of Operative Dentistry



Date

Nov 5 1981

Signature

ACKNOWLEDGEMENT

I am deeply indebted to Dr. Cornelis H. Pameijer, Professor and Chairman, Department of Biomaterials, who helped to initiate this research project. His constant advice and invaluable guidance made the completion of this project possible.

I am indebted to Dr. Lloyd B. Chaisson, professor and Chairman, Department of Operative Dentistry for his time and efforts in teaching operative dentistry.

I would like to thank Dr. Paul Ponte, Associate Professor and Director of Advanced Operative Dentistry, for his teaching efforts in operative dentistry. I would like to thank Mr. Arthur Bloom for his collaboration in taking photographs.

I am greatly indebted to my parents, FATAMEH, ALI for their affection and love.

I would like to thank my father-in-law SEYED HOSSIEN, for his efforts and love.

DEDICATION

This Thesis is dedicated to my beautiful beloved wife, MEHRNOOSH. Without her encouragement, patience and understanding this project may never have been completed.

With affection for my daughter MAHSA, whose presence has given life a very special meaning.

TABLE OF CONTENTS

TITLE PAGE	0
ABSTRACT	i
READERS' APPROVAL	iii
ACKNOWLEDGEMENT	iv
DEDICATION	v
TABLE OF CONTENTS	vi
INTRODUCTION AND STATEMENT OF PROBLEM	1
LITERATURE REVIEW	3
MATERIALS AND METHODS	22
RESULTS	26
DISCUSSION	31
SUMMARY AND CONCLUSION	33
BIBLIOGRAPHY	34
APPENDIX	40

INTRODUCTION AND STATEMENT OF PROBLEM

The efficacy of restorative materials to seal cavity margins against the entrance of salivary constituents has been of great interest to the dental researchers. Many studies have been done in both in vivo and in vitro in order to find a way for stopping or reducing the marginal leakage.

Many authors are offering their ideas about restorative methods using composites and acid-etched techniques for restoration of cavities.

The chemical and physical evaluations of composite resin fillings have been extensively investigated in the past (Lee and Swartz, 1970; Liatukas 1972), but still much has to be done to improve the mechanical properties of these materials. It is also important to achieve for each type of filling material the correct tooth contour in order to get the best possible esthetic and physiologic result and to restore the natural anatomy.

One of the widely accepted restorations with composite resin is the class V cavity. The Council on Dental Materials and Devices does recognize the usefulness of composite resins for class V and Class III restorations, Class V cavities are in the gingival one third of teeth and below the height of contour on labial, buccal and lingual surfaces of teeth.

This study will investigate the microleakage of a new visible-light-cured composite resin, namely Prismafil* in conventional and modified Class V preparations, with and without an intermediary bonding-agent, in comparison with Silar** and Profile***.

A conventional resin served as control group. The composite resin Adaptic was used for this purpose.

* 3M Company, 3 Center, Bldg. 555-IS, St. Paul, MN 55101

** S.S. White, Dental Products International, Phila., PA 19102

*** Caulk, Division of Dentsply International Inc., Milford, Delaware.

LITERATURE REVIEW

In recent years, there have been few aspects of dentistry that have stimulated more interest than the acid-etch techniques. These procedures have enabled dentists to attach materials and orthodontic appliances to the teeth without conventional undercuts or retentive devices. Since Buonocore's original observation, the refinements and applications of the acid-etch technique have become numerous.

Class V cavity preparations were chosen for this study because they are a popular candidate for composite resins fillings. Incorporating the advantage of bevels and the sealing properties of acid etch techniques along with a bonding-agent one can almost completely seal the class V cavities.

However, there are still several questions that arise when one considers composite resins and the application techniques.

1. How do acid etch bonding systems work on beveled enamel surfaces?
2. Does the application of a bonding agent and immediate placement of a composite resin produce a weakend composite restoration?
3. Does the amount of bonding agent have any effect on the marginal seal?
4. Does a thin edge of acid etch composite (beveled) produce a marked difference in long term sealing?
5. Does a thin edge of composite produce a weak margin?

Class V lesions are classified as smooth surface cavities occurring on the gingival third of the facial or lingual surfaces of

all teeth (The Art and Science of Operative Dentistry, 1976). For treatment of Class V lesions, amalgam, silicate cement, and composite resins may be used. When esthetics are a prime requirement, however, only silicates and composite resins can be used.

Composite resins refer to a three dimensional combination of at least two chemically different materials with a distinct interface separating the components, they are:

- a. Resin, organic
- b. Filler, inorganic

The filling is treated with a coupling agent to improve contact between the components.

The combination of these two materials provide properties that can not be obtained with any one of the components acting alone.

Incorporation of an inorganic filler in the resin give composite resin different properties than unfilled direct restorative materials. Recently micro-filled composite resin that may be visible-light cured, have been introduced.

Historical Background

For many years the dental profession has been looking for a restorative material which resembles the natural tooth in appearance and which can withstand the conditions within the oral cavity.

In 1871, translucent silicate cement was introduced by Fletcher, in England, but rejected because it was brittle and difficult to handle.

Steenbach in Germany modified the silicate and called it Ascher's Artificial Enamel. When a modification overcame the presence of a high degree of acidity the use of silicate cement spread.

The powders used for silicate cement are a complex glass consisting essentially of alumino-silicate containing magnesium, fluorine, calcium, sodium and phosphorus. One of the principal reasons for using silicate cement in anterior restorations is its lifelike appearance, at least when first inserted. A major weakness of silicate cement is their tendency to dissolve and disintegrate in the mouth especially in areas of the restoration which are not self cleansing.

Current silicate cements dissolve almost 0.8 percent, when one hour old specimens are immersed for 24 hours in distilled water (Phillips and Skinner). The presence of fluoride in silicate cement prevents recurrent decay at the margins, but the presence of acids has a potentially damaging effect on the pulp.

During World War II the Germans, to conserve metals, developed a self curing resin (plastic), then introduced into the United States with promise of replacing the silicate as anterior restorations. Acrylic resin consists of:

I. Polymer (powder) which is polymethylmethacrylate b, initiator, benzoyl peroxide (0.3-3.0%)

II. Monomer (liquid portion) is:

1. methylnmethacrylate
2. cross linking agents like ethylene dimethacrylate
3. Inhibitor - mono methyl of hydro quinone
4. Activator - dimethyl toluidine

Polymerization of acrylic resin can be accomplished in two ways, a) by formation of free radicals in which peroxide of powder react with the amine of liquid; b) p-toluene sulfinic acid which is

dissolved in monomer can initiate polymerization without adding benzoyl peroxide.

Acrylic resins are the softest of the restorative materials, they are susceptible to wear (e.g., tooth brushing), they have a high percentage of polymerization-shrinkage, low compressive and tensile strength and a high thermal coefficient of expansion (seven to eight times that of tooth structure). Due to temperature fluctuation of acrylic resins researchers developed ways to overcome these problems (Bead technique).

Some modified acrylic resins were developed, but the problem of high thermal coefficient of expansion and rise in temperature remained. The first practical monomer for use with composite resins was developed by Bowen in 1962, and it was a bi-product of bis phenol A and glycidyl methacrylate. Although Buonocore in 1956 identified the glycerophosphoric acid dimethacrylate, Bowen's work is the foundation of present dental adhesion technology.

Bowen's material is a Bis GMA which is a product of the bis phenol A and glycidyl methacrylate. Bis GMA is too viscous to be used directly. In order to improve its fluidity, lower viscosity substances are added, in the amount of 50% of its weight, e.g. methyl-methacrylate. Then inert, finely divided fillers are added for further modification and improvement. Filler is inorganic, chemically inert, hard, refractive, e.g. silica, quartz, borosilicate and its two main functions are, first to inhibit matrix deformation and second to decrease the coefficient of thermal expansion.

The surface of the filler is coated with a suitable coupling agent with stable adhesive bonding of the filler to the resin, which

is essential for strength and durability of the composite. An ideal composite resin has to have the following properties:

1. Meet general requirement of flow;
2. Cured composite must resist degradation by oral fluid;
3. Strong enough to withstand imposed mechanical forces;
4. Pose enough strength, so that, fracturing, dimensional instability or peeling will not result;
5. Good initial esthetic and preserve esthetics in the oral environment;
6. It should be tasteless, odorless, non-toxic and non-irritating to mouth tissues;
7. Good working characteristics.

But no composite has yet been found to meet all of these requirements. Compared to the acrylic resins the composite resins according to Ralph W. Philips (1976) have:

1. Greater compressive and tensile strength;
2. Higher modules of elasticity;
3. Superior resistance to abrasion and hardness;
4. Less polymerization shrinkage;
5. Lower coefficient of thermal expansion.

Thus composites are superior to the self-curing resins and silicate cements.

In a 1970 policy statement issued by the Council on Dental Materials, Ralph W. Phillips clarified and redefined composites as being those materials with sufficient filler content bonded to the resin matrix based on Bowen's Formula and processing the distinct properties of greater compressive strength and tensile strength,

higher modulus of elasticity , superior resistance to abrasion, lower polymerization shrinkage and a reduced coefficient of thermal expansion.

Phillips recognized the differences in properties of composites but dismissed their clinical significance at this time. He also pointed out problems in finishing of composite color stability, and the need for controlled studies to assess their use in class II and class IV cavity preparations.

Reisbeck (1971) evaluated the transverse strength of composites, and their ability to be added to zinc oxide eugenol as a base material. He found a significant reduction in transverse strength with ZOE as a base in the repaired restorations. Lee developed a product called HL-72, and a second product later known as EpoxyLite. Later, Lee formed his own company, Lee Pharmaceuticals, and produced a product similar to EpoxyLite, which was called Restodent.

In 1972, the first long term clinical investigation of four years duration was reported testing the composites Adaptic, Concise and EpoxyLite for class II, class IV and class V cavities with some restorations being treated with pins. None of the materials were singled out as being better. Pulp irritation proved to be a significant problem with composites.

In 1966, Langeland showed that pulp reactions to Addent are more severe compared to cold-curing acrylics, that zinc phosphate is not an adequate liner for composites and he drew the obvious conclusion that ZOE cannot be used as a base.

Stanley (1967) reported that composite materials can produce significant pulpal irritation and require the use of a base or liner

to protect the pulp. In 1972 Roberts and Moffa described the repair of a fractured permanent incisor with a composite resin, and a fissure sealant activated by ultraviolet light. Later they reported on 60 patients who were followed for two years.

Oppenheim and Ward (1973), Ellis and Davey (1970) have conducted studies about the efficacy of similar techniques. In a recent study a comparison of abrasion resistance between composites, unfilled resins, amalgam and glazing compounds was conducted, which resulted in the conclusion that composites with glass fillers were more resistant than those with fillers of lithium aluminium silicate.

Comparison with an unfilled resin, Sevricon showed a 40% higher rate of resistance to abrasion. Amalgam was found to be similar to the composite while the coating of glazing materials Finite and Nuva-seal abraded more quickly than the composites with which they were intended to be used.

In 1974, Eames, et.al, in a clinical trial compared composites and amalgams in posterior restorations and silicate and composites in anterior teeth. Composites performed well in both class I and class II restorations with no problems of fractures, however, loss of anatomy was seen with the composites after one year although their marginal adaptation after three years seemed superior. Silicates showed gross deterioration when compared to composites, particularly with respect to marginal adaptation and anatomic form.

The development of composite resin is continuing up to now and different types of composite resin, e.g., Adaptic, Concise, Exact, etc. have been developed. There are also other types of composite resins in addition to the conventional type.

1. Microfilled composite (5 mm fillers) e.g., Isopast, Isocap, which contain less inorganic components, possess a lower modulus of elasticity, higher value of water absorption and thermal expansion in comparison with highly filled composite resins. Properties of Silar are between those of microfilled and highly filled resin.

2. Micro-fine composite resins (0.05 mm) e.g., Silar has a lower modulus of elasticity, less water absorption, lower linear coefficient of thermal expansion compared to highly filled composites.

One of the newly developed dental materials are visible-light-cured composite resins.

According to Bassouing and Grant (1978), an important feature of the visible light cured composite is the generous working time it allows, and also its radiopacity, while the shade resembles that of dental enamel.

According to Smith and Wilson (1979) Fotofil restorations appeared to match the shade and translucency of adjacent teeth. Also the surface finish of Fotofil restoration was superior to that of comparable Adaptic restorations. The microfilled composite resin contain particles of silica smaller than 1 μm , and are designed to give smoother textures of finished surface.

Raptis, Fan and Powers (1979) in a study compared the physical and mechanical properties of microfilled composite with those of conventional composite resin. They found that Isopast, Isocap and Superfil compared with Concise, had lower amounts of inorganic filler contents and modulus of elasticity and higher values of water absorption, depth of indentation, and linear coefficient of thermal

expansion. The properties of Silar were between those of Concise and other microfilled composite resin.

In a summary of composite restorative materials in 1976, the Council on Dental Materials and Devices stated that the basic advantages of composites were the lower coefficient of thermal expansion. The lower polymerization shrinkage, the higher compressive strength and tensile strength, greater stiffness and lower water absorption. They concluded that this meant that composites had better marginal integrity, less marginal staining and secondary caries, less staining in the restorative material itself, and better maintenance of anatomic form compared to unfilled resins. So, rapid polymerization, ease of manipulation, good esthetics as well as improvement of different properties make the composite resins the most popular restorative materials.

With an understanding of enamel structure and microleakage, we have to find out what the acid etching does to tooth structure, and how it can help reduce microleakage. The supreme test of a filling is its ability to maintain an unfailing margin according to Prime (1937). Composite resin restorations are the first in the class of tooth colored materials to maintain marginal integrity during a clinically acceptable period.

There is evidence that crystalites of hydroxyapatite are preferentially arranged within the prisms. Each crystalite is elongated in shape, is too small to be seen with the ordinary light microscope, the direction of the elongation being along the fiber axis. A multitude of crystalites make an enamel prism, the fiber axis of which tend to be in a definite direction to the prism rather than

being arranged at random. Thulis (1940) confirmed that double orientation of crystalites in enamel appeared to exist; one group of prisms deviating about 5° from the prism axis, the other being interprismatic substance and deviating from the prism axis by 40° .

With contradictory findings by many researchers, Boyde (1976) concluded that enamel should be considered a continuous substance rather than made up of separate rod-like structures. Microleakage can be defined as the passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it.

In vitro experiments include the use of dyes, radioactive isotopes, air pressure, bacteria, neutron activation analysis, and artificial cavities techniques and thermal cycling. Thermal cycling occurred either in the range of 5-60°C or 15-45°C. Most investigators use a 30-60 second exposure time with a number of cycles up to 2500. Dyes and isotopes were used to assess microleakage and the results were quantified by assigning scores to the depth of penetration of these agents.

The characteristic brown ring around dental silicate and unfilled resin restorations was indicative of marginal leakage and accumulation of debris between the cavity wall and the restorative material. Marginal staining to this degree is no longer indigenous to tooth-colored restorations fabricated of composite resin placed on conditioned enamel.

Jordan and co-workers (1977) commented that the rare occurrence of marginal staining constitutes direct clinical evidence that acid conditioning of enamel margins enhances a marginal seal through an interlocking relationship between resin tags and etched enamel microporosities.

Gwinnett and Ripa (1973) stated that low viscosity resins that form tags on polymerization will penetrate enamel pores to depths of 20 to 50 um. Buonocore suggested that there may be 30,000 to 40,000 prisms per square millimeter of Enamel surface available for formation of tags. Therefore, acid etching produces a significant increase in the amount of surface area available for resin bonding and enhances the potential for sealing margins.

Hembree and Andrews (1976) in their studies of marginal leakage with dyes and radioactive tracers have corroborated this later finding. According to Going (1972), the application of a low-viscosity bonding agent and the use of rubber dam should be routine procedures for all composite resin restorations.

Many studies emphasize that the margins of restorations are not fixed, inert and impenetrable borders but rather are "dynamic microcrevices which contain a busy traffic of ions and molecules." Moffa, Robert and Jenkins (1973) found that the acid etch technique appears to be sensitive to microscopic surface contamination, which may result in non-adherence of composite resin to the tooth surface.

According to Voss (1979), the application of acid etching to enamel creates a more porous surface. When resin is applied to this surface, taglike projection of resin protrude into enamel. Mechanical retention of resin to enamel is thus created.

Voss and Charbeneau (1979) in a scanning electron microscope study have found that different enamel pre-treatment has no effect on the pattern and the length of resin tags. Aker, Aker and Sorenson (1979), on the other hand, showed that bond strength of composite resins is affected by the method of tooth preparation. They found that preparing enamel with a coarse diamond bur may provide a macroscopic roughness that adds to the microscopic roughness of the etching process and provides additional surface area for bonding Concise, Adaptic and Nuva-fil, but this roughness did not affect the retention strength of Restodent.

Khanna, Chow (1979) in a study found that a) different materials have different retentive strengths and the new materials like Concise and Adaptic systems have much higher in vitro retentive strengths than others tested; b) preparations in the enamel adjoining the tooth material interface, add significantly to the retentive strength of material.

Two basic mechanisms are responsible for retention of resin systems:

a. The wettability or ability of the resin to penetrate and adapt to etched surface.

b. The inherent strength of the resin tags.

The third factor could be related to the area of contact between enamel and resin.

Jordan, et al, (1977) in a clinical study, have shown that when a chamfer was prepared in enamel approximately 1 mm cervically from the fracture line, and to a depth of approximately one half the thickness of enamel, the dislodgement of the restoration was not related to the type of resin used.

It is apparent, therefore, that the chamfer increases the bonding strength of all materials to a degree sufficient to retain the restoration for prolonged periods.

Since the introduction of acid etch techniques it has been a controversial question whether an intermediary layer of low-viscosity, non-composite resin between composite material and etched enamel is beneficial. The influence of low viscosity resins has been investigated in studies on adaptation, retention strength and marginal leakage.

Jorgensen and Shimokobe (1975) demonstrated that composite resins adapt themselves to etched enamel surfaces equally well as do low viscosity resins. Mitchem and Turner (1974) and Adipranoto, Beech and Hardwick (1975) found that a coating of the etched enamel without intermediary resin prior to application of the composite did not increase the bond strength. Ortiz, et.al. (1976) found that the application of a low viscosity resin was an insignificant factor in marginal leakage.

On the other hand, Dogan (1976) showed that the frequency and length of tag penetrating into the etched enamel increased as the viscosity of the resin decreased.

Draughn (1976) found that the application of low viscosity resin caused a 50% increase in retention.

Hembree and Andrews (1976) demonstrated microleakage was greatly reduced or prevented only by the use of an intermediary resin of low viscosity. Lutz, Luescher and Ochsenbein and Muhlemann (1978) showed that combinations of a low viscosity sealant with a composite resin considerably improve marginal adaptation and inhibits microleakage in cavities prepared according to the principles of the adhesive restoration.

Fortiz, Phillips, Swartz and Osborne (1979) found that enamel etching resulted in a significant improvement in the bond strength and generally it decreased microleakage. On the other hand, the use of a bonding agent on enamel that has not been acid etched has little effect on microleakage.

In regard to cavity preparation for composite resin it is commonly believed that adhesive restorative techniques are very successful in the treatment of class III, IV and V restorations. Luescher, Lutz, Ochsenbein, Muhlemann (1978) showed that the best results in marginal adaptation and resistance to microleakage were obtained when adhesive restorative cavity preparation was combined with enamel etching and the use of a low viscosity resin.

Raadal (1978) found that a preventive composite filling seals occlusal fissures well, where acid etching of enamel is employed. The quality of the seal is independent of the

degree of dilution of the composite material, and temperature variations within limits of 40-60°C.

Sockwell, 1976, Bzorvatn, 1975; Charbeneau et al., 1975; Ibser De Ville, 1974 and Welk and Laswell, 1976, suggested that the conventional design of a cavity with a butt joint and retention cuts in dentin could be modified by beveling the cavo surface margin. It has been reported that beveling the cavo surface margin promotes adhesion of composite resins to enamel by increasing the surface of enamel in contact with composite resin (Sockwell, 1976; Ibsen Neville, 1974), improves esthetic (Bjorvatn, 1975), reduce marginal leakage (Welk, Laswell 1976; Hawkins et al., 1976). Kopel, Grenoble, Kablan, 1975; on the other hand, have found microleakage to be higher with a beveled, margin than with a butt joint.

Kempler, Stark, Leung, Greenspan (1975) in a study by means of scanning electron microscopy investigated the effects of thermal changes, mechanical abrasion and bonding agent on the enamel composite interface on class V cavities.

The conclusions of their study were as follows:

The combination of a butt joint in class V cavities to be restored with composite resins with acid etching and bonding agent, will provide a better seal at the enamel-composite interface compared with beveled joints.

The composite ledge over the beveled joint disintegrated under tooth brushing, exposing the enamel

composite interface. This did not happen to the same extent with the butt joint.

The use of bonding agent, improved the marginal seal significantly.

The wear resistance differed for different materials. The higher the resistance to wear, the longer will the enamel composite margin maintain its integrity.

Acid etching, followed by the application of a bonding agent prior to placement of a composite is recommended.

Hembree and Andrew (1978) designed a study to evaluate the marginal leakage of abraded gingival areas in extracted teeth using five composite resin acid etch restorative materials and a glass ionomercement, ASPA.

They used Simulate, Cervident, and Concise. A layer of unfilled resin (intermediary bonding agent) was between the etched tooth surface and the composite resin. Restodent and Enamelite were placed directly on the etched tooth surface. The result of the study indicated that there is a significantly greater degree of marginal leakage at the gingival margin than there is at the occlusal or incisal margin of composite restorations. In addition, greater degrees of marginal leakage were observed in those restorations where no layer of unfilled resin was placed between the etched tooth surface and the composite resin. The glass ionomer cement showed no marginal leakage at intervals of one day, three months, and six months; however, a small amount of leakage was observed at the incisal or

occlusal and gingival margins after a year and half on the autoradiographs.

Hembree (1980) prepared eighty class V cavities in human teeth. The teeth were divided into four groups as follows:

1. Butt-Joint cavo surface;
2. Butt-Joint cavo surface preparation, overfilled and finished beyond the cavo surface angle;
3. Butt-Joint preparation modified by beveling the enamel cavo surface (1 to 1.5 mm long);
4. Butt-Joint preparation modified by cutting a 1 mm shoulder in the enamel approximately one half the thickness of enamel, and a shoulder prepared with a no. 6b diamond stone.

The teeth were restored with and without acid etching and enamel bond.

The butt-joint preparation with neither etching nor enamel bond exhibited significant leakage. In the restorations where the cavo surface angle was etched and an enamel bond was used minimal leakage was demonstrated. The butt-joint/overfilled preparation without etching or enamel bond showed leakage similar to the preparation having only the butt-joint. When the cavo surface angle was etched and the enamel bond applied, the leakage was significantly reduced. The butt-joint preparations demonstrated leakage similar to the butt-joint and butt-joint/overfilled groups. With the use of acid etching and enamel bond, the leakage patterns were similar to the butt-joint/overfilled preparation.

It should be mentioned that preparing a cavo surface bevel is more desirable than overextending the composite resin, since the restoration can be finished to a proper contour. The result of shoulder-joint preparations were similar to the other cavity designs.

From the results of this study, one may conclude that composite resin restorations without acid-etching and bonding agent exhibited significant microleakage, regardless of the type of cavity design used, and the marginal leakage was significantly reduced or eliminated in preparations where the enamel at the cavo surface angle was etched and a layer of unfilled resin was placed before insertion of the restoration.

MATERIALS AND METHODS

Three commercial composite resins were used in this study.

1. Silar*, which is a microfilled composite. Inorganic silicon dioxide with an average particle size of 0.04 microns comprises about 52% of the restoration. It's coefficient of thermal expansion (10°-50°C) is $50 \times 10^{-6} \text{PPM}/^{\circ}\text{C}$.

2. Profile**, is an 80% strontium glass filled composite resin. By comparison, strontium glass is a softer, more resilient material than quartz, and its particles are more irregular in shape. It's coefficient of thermal expansion is $35^{\circ}\text{PPM}/\text{C}$.

3. Prismafil*** is a new composite resin containing microfine particles averaging 5 microns - 75% by weight in a resin matrix. It is supplied in four shades - light, light

yellow, light grey, and grey brown. The preblended shades of Prismafil come in syringes. Prismafil cures by prima-lite up to a depth of 2.5 mm.

Adaptic was used in the control group.

Eighty permanent teeth were used for this study. They were cleaned with pumice and stored in 10% formalin. The eighty teeth were divided in 10 groups of 8 teeth. The first group was the control group in which conventional class V cavity preparations were made at the cemento-enamel junction on the buccal side of the teeth with a high speed hand piece under water cooling. Final finishing was completed with hand instruments. The cavities were dried with compressed air. The cavities were filled with Adaptic mixed according to the manufacturer's instructions without the use of a bonding agent.

* 3M Company, 3 Center Bldg, 555-IS, St. Paul, MN 55101

** S.S. White, Dental Products International, Phila.PA 19102

***Caulk, Division of Dentsply International Inc., Milford,
Delaware.

In Group II class V cavities were prepared in the same way as in the control group. The cavities were restored with Prismafil; the material was used according to the manufacturer's instructions.

Group III was prepared with a conventional preparation and filled with Prismafil after the cavity had been etched with 50% phosphoric acid and a bonding agent was applied.

In group IV the cavo surface margin was beveled to an angle of 45°. A round bur was used to produce the bevel. The acid-etch bonding technique was applied.

Group V samples were prepared with a conventional preparation, and filled with Profile. No acid-etch or bonding agent was employed.

In group VI the teeth received a conventional preparation and were filled with Profile after the cavity had been etched, and a bonding agent was applied.

Group VII. Profile was used in a modified preparation similar to Group IV. Acid-etch and bonding agent was employed.

Group VIII. Silar was used in a conventional preparation, no acid-etching or bonding agent was employed.

Group IX. A conventional preparation was made followed by acid-etching and the application of a bonding agent. Silar was used as filling material.

Group X. The cavo surface margin was beveled to an angle of approximately 45 degrees, producing a cavo surface

angle of 135 degrees. The acid-etch, bonding agent technique was applied.

In all groups the material was mixed according to manufacturer's instructions and retained into the cavity with a Mylar matrix band. Care was taken to ensure that acid was confined to the enamel. The etchant was applied for one minute, after which time the cavities were washed with distilled water and dried with compressed air, then the bonding agent was applied prior to the application of the material.

In all groups, the excess composite resin was removed with a diamond bur and the restoration finished with strips and polished with a rubber wheel. The teeth were rinsed and dried. They were then completely covered with a thermoplastic cement no. 40-8100 (Buehler Ltd.) leaving 2mm enamel around the cavity outline uncovered.

The purpose of using this cement was to prevent dye penetration into the teeth via other openings than the margin of the restorations. The teeth were subjected to a thermal cycling in water containing methylene blue. The temperature of the two containers was 5°C and 60°C. The teeth were 25 seconds in each container, with an interchange interval of 10 seconds. All teeth were cycled 1000 times.

The specimens were sectioned longitudinally in a bucco-lingual plane using an Isomet low speed saw* with a diamond wafering blade No. 11-4244. The sections were examined in a light microscope at different magnifications

to determine the presence of leakage. The sections were scored for dye-penetration as follows:

- 0 No Leakage
- 1 Leakage in enamel only
- 2 Leakage along enamel into dentin
- 3 Leakage to the floor of the cavity towards the pulp.

* Buehler LTD, 2120 Greenwood Street, Evanston, Illinois 60204.

RESULTS

Results are shown in Table I, and will be discussed in detail for each individual group.

Group I. This group was the control group. A conventional composite resin was used in a conventional preparation. No bevel or acid-etching was employed. Analysis of the scores demonstrate a majority of #3 scores meaning that dye penetration was quite severe and extended to the floor of the cavity. One sample proved to be better than the average.

Group II. Prismafil was used in a conventional preparation. No bevel or acid-etching was employed. Analysis of scores demonstrate a majority of #3 scores indicating that the marginal leakage was quite severe. One sample showed no marginal leakage at all.

Group III. Prismafil was used in a conventional preparation. Acid etching and bonding agent was applied. Analysis of the scores demonstrate a majority of #2 score meaning that dye penetration was not as severe as Group II. One sample showed no marginal leakage.

Group IV. Prismafil was used in a modified preparation 45° bevel. Acid etching and bonding agent were employed. The scores recorded were mainly a #1 score pointing towards leakage into enamel only. Two samples showed dye penetration into dentin.

Group V. Profile was used in a conventional preparation without acid-etching. The scores were mainly in the range of #3 and #2 meaning that the marginal leakage was rather severe. One sample proved to be better than the average.

Group VI. Profile was used in conventional preparation. Acid-etching and bonding agent were employed. A majority of #2 scores were recorded. Two samples showed dye penetration into enamel only.

Group VII. Profile was used in a modified preparation with a 45°bevel, acid-etching and bonding agent were employed. In this particular group #1 was predominantly recorded. Two samples showed no marginal leakage at all and one sample was below the average.

Group VIII. Silar was used in conventional preparation. No acid-etching was employed. Analysis of the scores demonstrates a majority of #2 scores, indicating similarity with other conventional groups. Three samples showed marginal leakage into enamel only.

Group IX. Silar was used in a conventional preparation whereas acid-etching and bonding agent were employed. There a majority of #1 scores was recorded. Three samples showed dye penetration into dentin and one sample showed no marginal leakage.

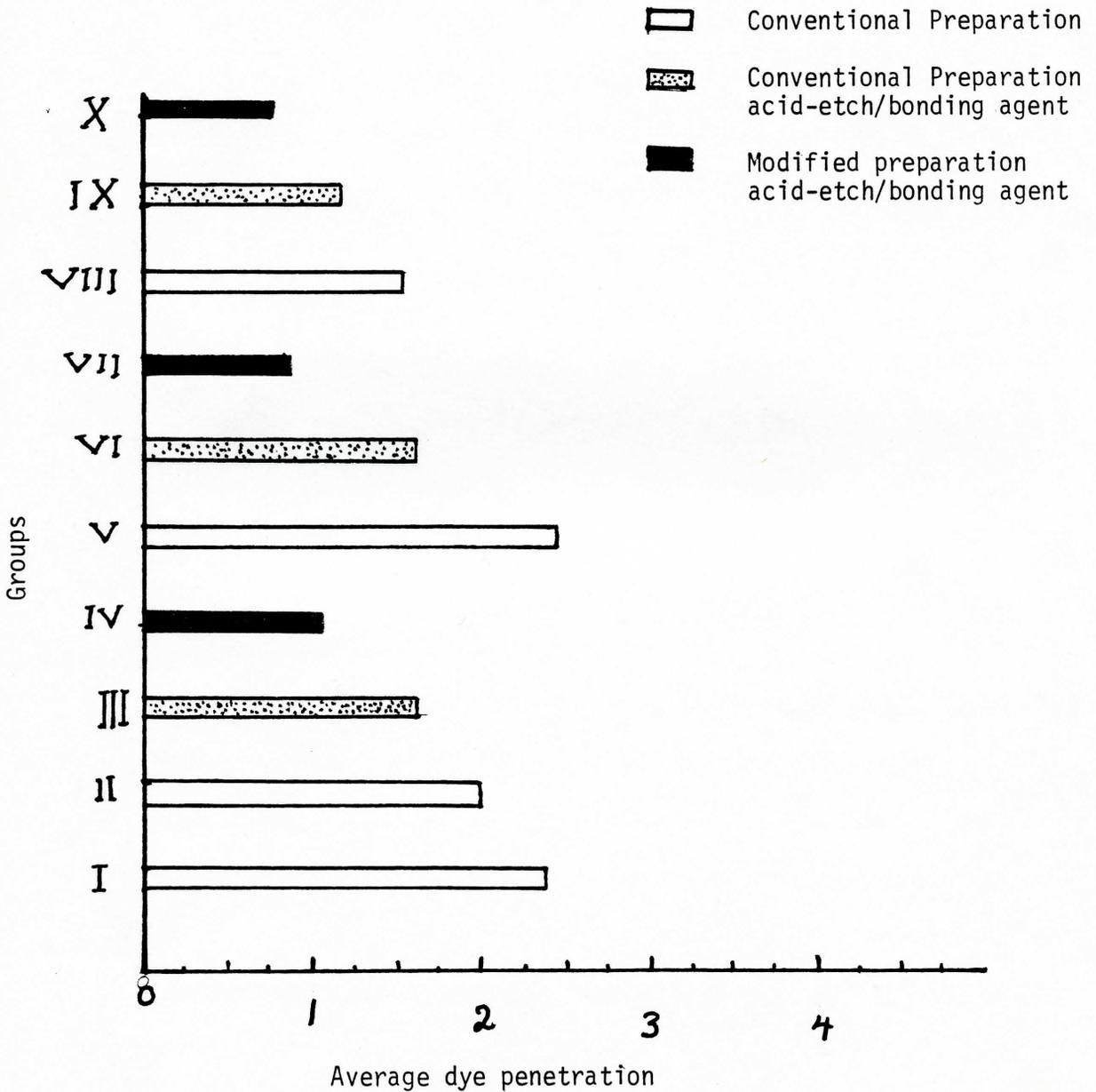
Group X. Silar was used in a modified preparation with a 45°bevel, acid etching and bonding agent. This group was also mainly in the score #1 category. Three samples showed

no marginal leakage. One sample shows dye penetration into dentin.

Table I - Degree of Penetration of Dye Between
The Restoration and Tooth

GROUP	SCORES
I (Control Group)	3-2-3-1-2-3-3-2
II Prismafil Conventional Prep.	3-3-1-0-3-2-2
III Prismafil Conventional Prep. Acid Etch Bonding Agent	2-2-0-2-1-2-2
IV Prismafil Modified Prep/Acid Etch Bonding Agent	2-0-1-1-1-1-2-1
V Profile Conventional Prep	3-1-2-3-2-2-3
VI Profile Conventional Prep Acid Etch/Bonding Agent	2-2-2-2-1-1
VII Profile Modified Prep. Acid Etch/Bonding Agent	2-1-0-1-0-1-1
VIII Silar Conventional Prep	2-2-1-1-2-1-2
IX Silar Conventional Prep. Acid Etch/Bonding Agent	1-1-1-2-1-0-2-2
X Silar Modified Prep. Acid Etch/Bonding Agent	1-1-0-1-1-0-2-1

Seven specimens were damaged during processing and not suitable for evaluation.



Bargraph I. Average dye penetration scores in treatment groups I to X.

DISCUSSION

In Vitro studies like this one cannot be directly equated with the clinical situation. In the oral cavity the fillings are exposed to chemical and mechanical stresses (Jorgensen, Matono and Shimokobe 1976) in addition to the thermal changes here examined. The use of dye and direct inspection through an electron microscope, rather than a complicated radioisotope technique has been shown to be an informative and flexible method (Ericksen, Buonocore 1976).

The results in Table I show that for all three composite systems used, with a beveled cavo surface, there was less microleakage. The bonding agent decreased microleakage. It is evident that the best seal at the enamel composite interface was achieved by a cavo surface bevel with bonding agent and acid etch.

The use of acid etching with composite resins has been widely documented. The concept of etching the enamel has been accepted and is considered to be an integral part of the composite restorative technique. It has been reported recently that the bond between composite and etched enamel becomes stronger with age and stress (Goos, Nachtsheim, Langager 1976).

Temperature shifts have been reported to cause increases and decreases in the width and gap at the enamel-composite interface (Ibsen, Neville, 1974; Going, 1972). Etching with acid may reduce the gap under elevated

temperatures but cannot eliminate it. The use of a bonding agent may be important in this regard, as the bonding agent creates chemical bonds between the composite resin and calcium ions of the hydroxyapatite.

Nevertheless, concern has been expressed in regard to solubility of those materials (Ibsen, Neville, 1974; Lee, 1966; Cornell, 1961). The combination of acid etching and bonding agent seems to provide the best result. This combination has been reported to virtually eliminate marginal leakage (Galan, Mondell, Coradazzi, 1976; Dogan, 1975).

As to the configuration of cavo surface margin, from the results in this study it is evident that beveled cavo surface provides better results than the conventional cavo surface. These results confirm the results of Kopel, Grenoble, Kaplan (1975).

Although there was not a significant difference between three composite resins used in this study, related to microleakage, Profile proved to be better than the other two composite resins.

SUMMARY AND CONCLUSION

The study was designed to evaluate the marginal leakage of visible light cured composite resin, in class V preparations. Silar and Profile composite resins were used for the comparison and Adaptic in the control group. Eighty extracted human teeth were divided into 10 groups, and conventional and modified class V preparations were made.

Some of the preparations were etched with acid and coated with bonding agent. After restoring the cavity preparations with the composite resins, the teeth were subjected to thermal cycling between 5°C and 60°C.

All teeth were tested for microleakage and examined by means of a stereo microscope. The best results were obtained in combining beveled margins with acid etching and bonding agent. Profile appeared to be the best of three tested composite resins.

BIBLIOGRAPHY

- Aker, D..A., Aker, J.R., Sorensen, S.E.: Effect of methods of tooth enamel preparation on the retentive strength of acid-etch composite resins J. Amer. Dent. Assoc. 99:185, 19759
- Asmussen, E: Penetration of restorative resins into acid etch enamel. I. Acta Adont. Scand., 35:175, 1977
- Aspes, T., McElwain, J.E.Jr.: The Multiple uses of acid-etch techniques. Dent. Surv. 50:25, 1974
- Bassiouny, M.A., Grant, A.A.: A visible light-cured composite restorative, Brit. Dent. J., 145:327, 1978.
- Bjorvatin, K.: The use of acid-etch technique in pedodontics in Scandinavia: Clinical and technical studies in the acid etch technique. Proc. Int. Symp., eds. Silverstone, St. Paul, MN. 1975, pp 230-237.
- Buonocore, M.G.: Adhesives in the prevention of caries, J. Amer. Dent. Assoc. 87:9, 1973, pp 1000-1005.
- Charbeneau, G.T., Cartwright, C.B., Comstock, F.W., Kahler, F.W., Snyder, D.T., Dennison, J.B. and Margeson, R.D.: Principles and Practice of Operative Dentistry, Phila. Lea and Febiger, 1975, pp 316-317.
- Cornell, J.: Adhesion to natural teeth in Adhesive Restoration Dent. Materials, ed. Phillips, R.W. p. 159, Spencer IN: Owen Litho Service, 1961.
- Dogan, I.L.: Studies demonstrating the need for an intermediary resin of low viscosity for the acid-etch technique. Proc. Inc. Symp. Acid Etch Techn. North Central Publishing Co., St. Paul Minn. U.S.A., 1975, pp 100-118.
- Dogan, I.L.: The influence of viscosity on the penetration of resin into acid-etch enamel, J. Dent. Res. 55, Special Issue B, abstract No. 303, 1976.
- Draughn, R.A.: The effect of thermal cycling on

- retention of composite restoratives, J. Dent. Res. 55, Special Issue B, abstract No. 303, 1976.
- Ellis, R.G., Davey, K.W.: The classification and treatment of injuries to the teeth of children. A reference manual for the dental student and general practitioner, ed. 5, Chicago Year Book Medical Publishers, 1970.
- Eriksen, H.M., Buonocore, M.G.: Marginal leakage with different composite restorative materials effect of restorative techniques, J. Amer. Dent. Assoc. 93:1143-1148., 1976.
- Eriksen, H., Pears, G.: In Vitro caries related to marginal leakage around composite resin restoratives, J. Oral Rehab., 5:15, 1978.
- Flynn, M.: Scanning electron microscope investigation of in vivo performance of eight composite resins, J. Prosthet. Dent., 39:529, 1978.
- Fox, D.J., Pappas, P.: Use of acid-etch resin in heritary enamel hypoplasia: report of case. J. Dent. Child, 42:137, March-April, 1975.
- Galan, J., Jr., Mondelli, J. and Coradazzi, J.L.: Marginal leakage of two composite restorative systems, J. Dent. Res. 55, 1976.
- Glyn Jones, J.C., Grieve, A.R., Kidd, E.A.M.: An in vitro comparison of marginal leakage associated with three resin based filling materials, Brit. Dent. J., 145:299, 1978.
- Going, R.E.: Microleakage around dental restorations A summarizing review, J. Amer. Dent. Assoc. 84: 1349-1357, 1972
- Going, R.E., Reducing marginal leakage: A review of materials and techniques, J. Amer. Dent. Assoc. 99:646, 1979.
- Gwinnett, A.J., Ripa, L.W., Penetration of Pit and fissure sealants into conditioned human enamel in vivo. Arch Oral Biol. 18:435,1973
- Habeshian, H., Acid-etching composite resin techniques as an adjunct to operative dentistry procedures,

Quintessence Inc. 8 9:25-29 Sept 77.

- Hembree, J.H.: Microleakage of composite resin restorations with different cavo surface design. J. Prosthet Dent. 44:2 Aug. 1980 pp171-174
- Hembree, J.H.: Andrews, J.T.: Microleakage of several acid-etch composite resin systems: a laboratory study, Oper. Dent. 1:91, 1976.
- Hembree, J.H., Andrews, J.T.: Microleakage evaluation of eight composite resins, J.T. Prosthet. Dent. 44:3, Sept 1980, pp 279-282
- Hembree, J.H., Andrews, J.T.: Microleakage of several class V anterior restorative materials: a laboratory study J. Amer. Dent. Assoc. 97;pp 179-182, Aug. 1978.
- Hembree, J.H. Andrews, J.T: In Vitro microleakage of several acid-etch composite systems. J. Dent. Res. 55, Special Issue B, Abstract No. 309
- Ibsen, R.L., Neville, K: Adhesive Restorative Dentistry, Philadelphia, W.B. Saunders Co. 1974 pp. 11, 51-63.
- Jordan, R.E. and others: Restorations of Fractured and hypoplastic incisors by the acid-etch resin technique: a three year report. J. Amer. Dent. Assoc. 95 (4): 795-803, 1977.
- Jorgensen, K.D., Matono, R., Shimokobe, H.: Deformation of cavities and resin fillings in loaded teeth, Scand. J. Dent. Res. 1976: 84:46-50.
- Jorgensen, K.D., Shimokobe, H.: Adaptation of resinous restorative materials to acid-etched enamel surfaces, Scand. of Dent. Res. 83.31-36, 1975.
- Kempler, D., Stark, M.M., Leung, R.L., and Greenspan J.S.: Enamel composite interface relative to cavo surface configuration, abrasion, and bonding agents, Oper. Dent. 1:137, 1975.
- Khanna, S.L., Chow, J.: Comparison of four composite materials and effect of tooth preparation on bond strength, J. Dent. Child. 19:379, 1979.

- Kopel, H.M., Grenoble, D.E., and Kaplan, C.: The effect of cavo surface treatment on marginal leakage of composites, J. of the Calif. Dent. Assoc., 3, 56-62, 1975.
- Lee, H.L.: Advances in the synthesis of epoxy resins for adhesion to dry and wet tooth structures. In Adhesive Res. Dent. Materials, ed. Austin, R.H., Wilsdorf, H.G.L. and Phillips R.W. vol 2, U.S. Public Health Service Publ. No. 1494 pp 232-257, 1966, Washington D.C. U.S. Government Printing Office.
- Low, T., Lee, K.W., von Fraunhafer, J.A.: The Adaptation of Composite materials to etched enamel surfaces, J. Oral Rehab., 5:349,1978
- Luescher, B., Lutz, F., Ochsenbein, H., Muhlemann, H.R.: Microleakage and Marginal adaptation in conventional and adhesive class II restorative J. Prostht. Dent., 37:301,1977
- Luscher, B., Lutz, F., Ochsenbein, H., Muhlemann, H.R.: Microleakage and marginal adaption of composite resin restoration, J. Prosthet. Dent. 39:409, 1978.
- Oppenheim, M., Ward, G.T.: The restoration of Fractured incisors using Nuva-Seal and Adaptic, J. Dent. Res., 52 Special Issue, 185 Abstract No. 507, Feb. 1973.
- Ortiz, R.F., Philips, R.W., Swartz, M.L., Osborne, J.W.: Effect of Composite resin bond agent on microleakage and bond strength, J. Prosthet. Dent., 39:409, 1978.
- Prime, J.M.: Inconsistencies in Operative Dentistry, J. Amer. Dent. Assoc., 24(1):82-85,1937.
- Quist, V., Qvist, J.: Marginal leakage along concise in relation to filling procedures, Scand. J. Dent. Res., 85:305, 1977.
- Raadal, M.: A follow-up study of sealing and filling with composite resins in the prevention of occlusal caries, Community Dent. Oral Epidemond 1978: 6: in press.

- Raadal, M.: Bond strength of composite applied to acid-etched enamel, Scand. J. Dent. Res., 86:157, 1978.
- Raadal, M.: Microleakage around preventive composite fillings in occlusal fissures, Scan. J. Dent. Res., 86:495, 1978.
- Rajstein, J., Tal, M: A study of the contour and external surface of class V composite resin fillings. J. Oral. Rehab., Sept-Oct.78, 57:9-10, pp 879-80
- Raptis, C.N., Fan, P.L.: Powers, J.M.: Properties of microfilled and visible light cured composite resin J. Amer. Dent. Assoc., 99:631, 1979.
- Roberts, M.W., Moffa, J.P.: Repair of fractured incisal angles with an ultraviolet light activated fissure sealant and a composite resin: two year report of 60 cases, J. Amer. Dent. Assoc., 87:888, Oct. 1973.
- Roberts, M.W., Moffa, J.P.: Restoration of fractured incisal angles with an ultra-violet activated sealant and a composite resin. A case report, J. Dent. Child. 39:364, Sep-Oct. 1972.
- Roberts, M.W., Moffa, J.P.: Jenkins, W.A.: Clinical evaluation of three acid-etch composite resin system; two year report, J. Amer. Dent. Assoc. 97:829, 1978.
- Silverstone, L.M.: Fissure sealants, laboratory studies, Caries Res. 8:2-26, 1974.
- Skinner, E.W., Phillips, R.W.: The Science of Dental Materials, 6th edition, W.B. Saunders, Phila. PA, 1968.
- Smith, G.A., Wilson, N.H.F.: A visible light-cured composite restorative, Brit. Dent. J., 147:185. 1979.
- Sockwell, C.L.: Clinical evaluation of anterior restorative materials, Dental Clinics of North America, 20, 403-422.
- Swartz, M.L., and Phillips, R.W.: In Vitro studies

on the marginal leakage of restorative materials
J. Amer. Dent. Assoc. 62:141, 1961.

Torney, D.L.: The retentive ability of acid-etched
dentin, J. Prosthet. Dent. 39:2, Feb. 78,
pp 169-72.

Voss, J.E., Charbeneau, G.T.: A Scanning electron
microscope comparison of three methods of
bonding resin to enamel rod ends and longitudinal
cut enamel. J. Amer. Dent. Assoc. 98:384, 1979.

Welk, D.A. and Lawell, H.R.: Rationale for designing
cavity preparations in light of current
knowledge and technology. Dental Clinics of
North America., 20,231-239.

FIG. 1

Cross section of a composite restoration in Group I (Control Group). Marginal leakage can be seen along the interface composite enamel/dentin. This particular restoration received a score of 3.

FIG. 2

Cross section of composite filling Adaptic in Group I. Marginal leakage can be observed.

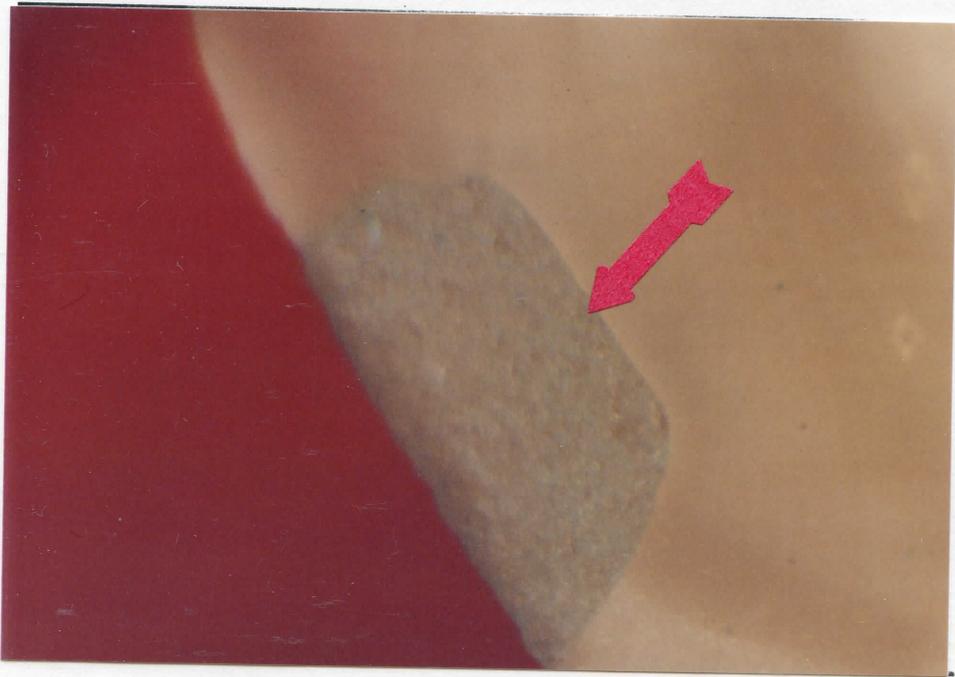


FIG. 3

Cross section of Prismafil in an unetched cavity (Group II). The dye has penetrated along the enamel wall of the cavity following thermal cycling penetrating into dentin almost reaching the floor of the cavity preparation..

FIG. 4

Cross section of Prismafil in an etched conventional cavity with bonding agent (Group III). The dye has penetrated along the lateral wall of the cavity reaching the floor of the cavity.

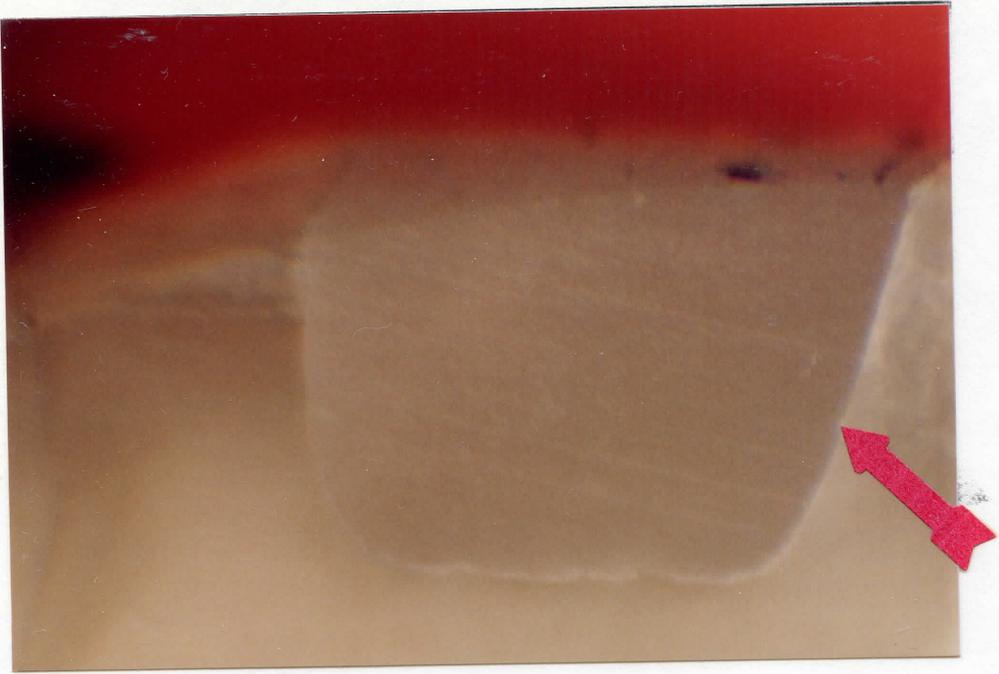


FIG. 5

Cross section of Prismafil in etched modified class V cavity with bonding agent (Group IV). No marginal leakage can be observed.

FIG. 6

Profile in an unetched conventional class V preparation (Group V). The dye has penetrated to floor of cavity and has spread along the floor of the preparation indicative of severe leakage (Score #3).

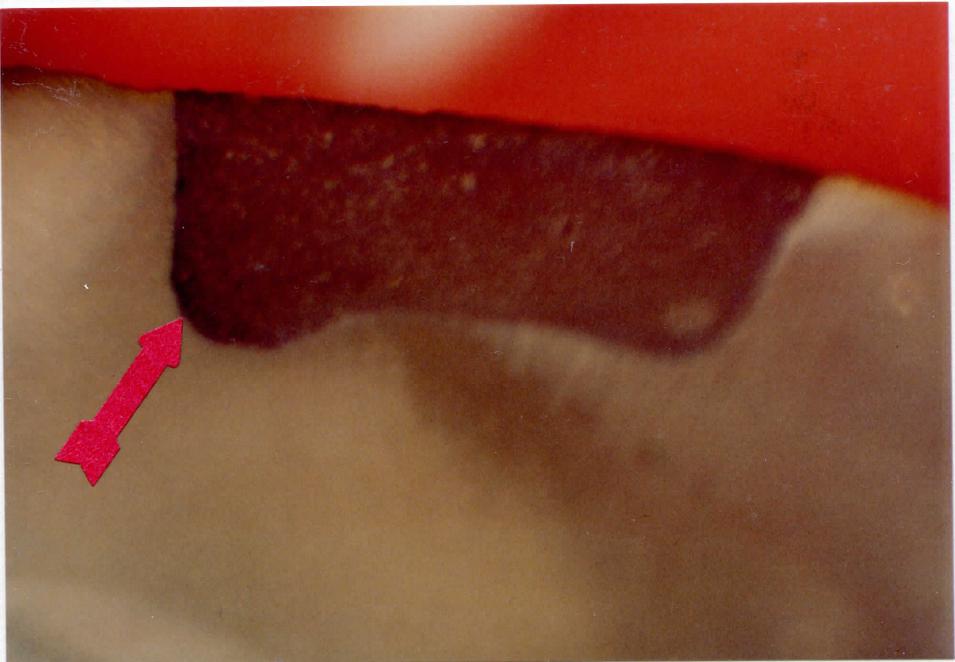
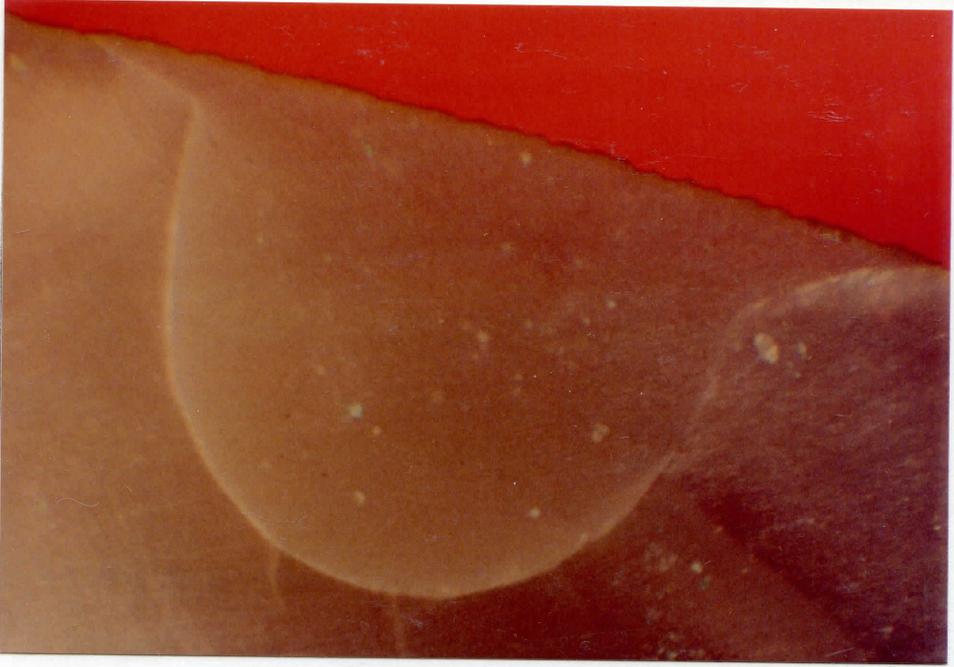


FIG. 7

Cross section showing profile in an etched conventional class V preparation with bonding agent (Group VI) Marginal leakage can be detected into enamel only.

FIG. 8

Cross section of profile in modified etched cavity with bonding agent (Group VII). Marginal leakage up to enamel can be detected.

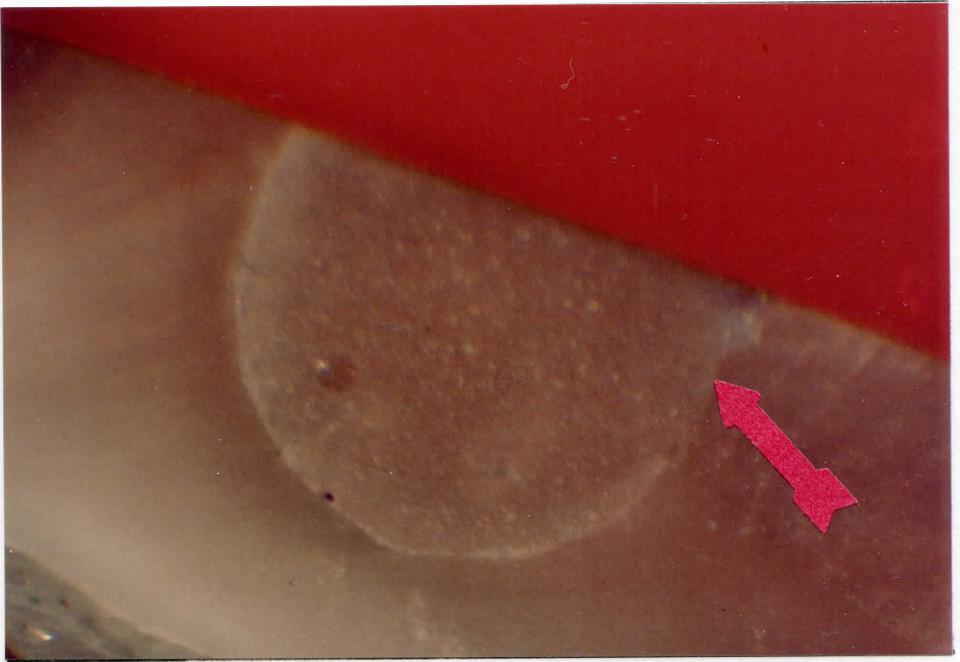
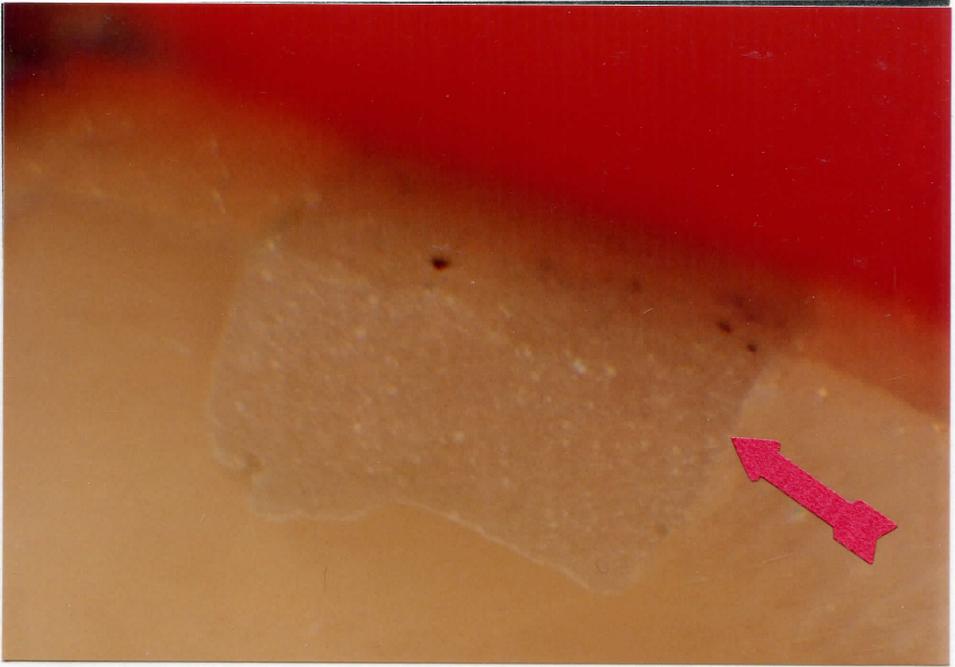


FIG. 9

Cross section showing
Silar in an unetched
cavity (Group VIII).
Dye has penetrated
along dentin toward
floor of cavity.

FIG. 10

Cross Section of Silar
in an etched cavity with
bonding agent (Group IX).
Minor marginal leakage
can be detected

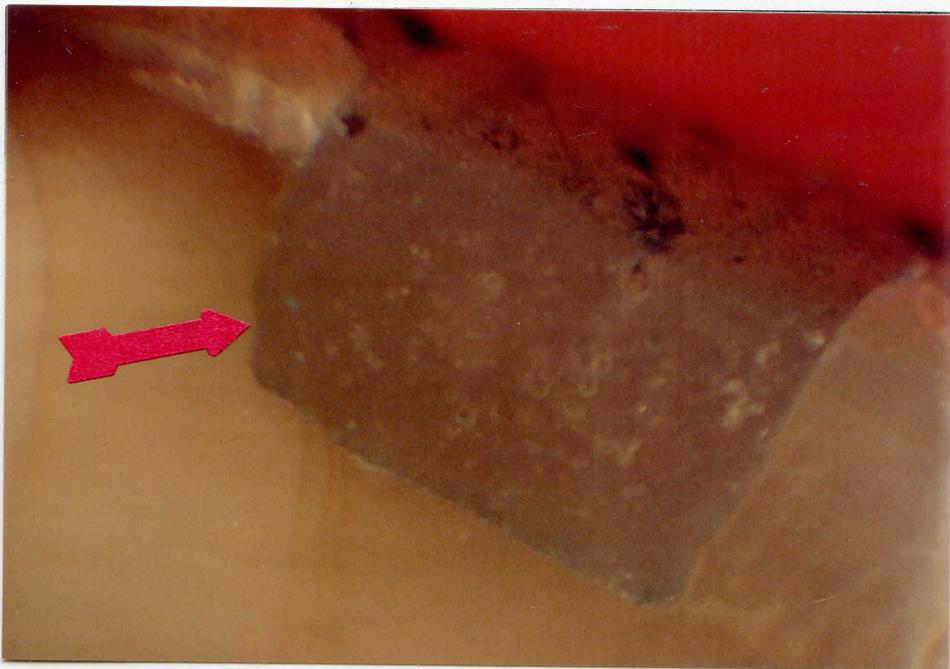


FIG. 11

Cross section of Silar
in an etched modified
class V with bonding
agent (Group X). No
marginal leakage was
observed.

