3M

F2000

Compomer Restorative System

Technical Product Profile

Table of Contents

Introduction

Dental restorative materials have changed and the market has grown significantly in the past years. In 1990, the global market for directly placed dental restorative materials included amalgam, composite and glass ionomer products. In 1992, resin-modified glass ionomer restorative products were introduced and 3M became a leader in this category with 3M™ Vitremer™ Tri-Cure Glass Ionomer System, currently known as 3M™ Vitremer™ Core Buildup/ Restorative. In late 1993, a compomer, yet another new category of directly placed restorative material was introduced into the marketplace.

To put this newer category of material into further perspective, let us review the general composition, advantages and disadvantages of the various types of directly placed, tooth-colored dental restorative materials, i.e. composite, conventional glass ionomer, resin-modified glass ionomer and compomer.

Composite

Dental composites are made of a resin, usually a hydrophobic resin, and an inert filler. They cure by free radical polymerization initiated by light and/or by chemical means. While these materials can be segmented into different types such as microfills, hybrids, etc., they share many advantages. They are highly esthetic, have excellent strength properties and are wear resistant for their intended uses. Dentists are very familiar with their use and they are thus, convenient to use. Some disadvantages of dental composites are that they are time-consuming to place and finish in some clinical situations, they are sensitive to the presence of moisture and they have no fluoride release.

Conventional Glass Ionomer

The conventional glass ionomer restorative products are composed of a polycarboxylic acid, a fluoro-aluminosilicate (FAS) glass and water. They set by an acid-base reaction and metal chelation which occurs when their constituents are mixed together. The advantages of these materials are many. They exhibit high initial fluoride release and continue to release fluoride over a long period of time. They chemically bond to both enamel and dentin and show excellent clinical retention. They have excellent thermal properties. A major disadvantage of these materials is that they are powder/liquid systems that require mixing either by hand or mechanically. They are technique sensitive being particularly sensitive to the presence of moisture during placement and desiccation after placement. They have long set times and cannot be finished immediately after setting. Compared to composites, they generally have lower strength and poorer esthetics according to some dentists.

Resin-modified Glass Ionomer

The resin-modified glass ionomer restorative products are comprised of a methacrylated polycarboxylic acid, FAS glass and water. These materials have multiple setting mechanisms. They harden by the same reaction as that of the conventional glass ionomer materials and additionally, cross-link through their methacrylate functionality. In the tri-cure systems such as 3M Vitremer core buildup/restorative, the cross-linking can be initiated by light and/or by chemical catalysts. The resin-modified glass ionomers have all of the advantages of the conventional glass ionomer products plus they are easier and more convenient to use, can be finished immediately after curing, have significantly greater strength and improved esthetics. The disadvantages that remain with these products are that they are still powder/liquid systems that require mixing and have only medium strength compared with that of composites.

Compomer

The word “compomer” is derived from “composite” and “ionomer” and is descriptive in that the materials combine features of both these types of dental materials. Compomer restorative products are made of a carboxylated methacrylate resin and FAS glass filler. As with popular dental composites, current compomers set by light-initiated polymerization. These products are one-part pastes packaged primarily in capsules. Used with their respective adhesive agents, they can usually be placed without a traditional phosphoric acid etch procedure. They are considered to have good handling characteristics. These latter features combine to make compomers easy-to-use. Further, they have good esthetics and show sustained fluoride release. Disadvantages of the current compomers are that they have lower wear resistance than that of composites and lower fluoride release than that of most glass ionomers.

If one were to consider a continuum of these directly placed, tooth colored dental restoratives as described by Burgess et al., based on material compositions, curing mechanisms, properties, performance, etc., it could look like the schematic below with conventional glass ionomer at one end of the continuum and composite at the other. The resin-modified glass ionomer would best fit nearer the conventional glass ionomer given its closer similarity to this category though it also has similarities to dental composite. The compomer would best fit nearer composite given its similarity to this material category though it has features of glass ionomer. Each material category has significant advantages and some disadvantages. With the various types of materials available, dentists today have greater options to tailor their material choices to the specific needs and desires of their patients.

Conventional GI	**RMGI**	**Compomer**	**Composite**

The 3M™ F2000 Compomer Restorative System

Description of System

The 3M F2000 Compomer Restorative System includes the 3M™ F2000 Compomer Restorative and a 3M primer/adhesive system for bonding the compomer to tooth structure. Bonding can be accomplished using the 3M™ F2000 Compomer Primer/Adhesive in the 3M™ Clicker™ Dispenser or a 3M dental adhesive system.

The F2000 compomer restorative is a one-part, light curable, fluoride releasing, radiopaque paste. It has high physical properties and exceptional handling characteristics. It is packaged in both single-use capsules and multi-dose syringes. It is available in 13 shades, 9 Vita® shades and 4 specialty shades.

Vita shades—A2, A3, A3.5, A4, B2, B3, C2, C4, D3

Specialty shades—Pedo, CY (cervical yellow), CG (cervical grey) and Blue

The blue shade is specifically designed for core buildup applications to provide a distinct color difference from tooth structure.

The F2000 Compomer Primer/Adhesive is a two-part liquid primer/adhesive. It is indicated for bonding F2000 compomer restorative to tooth structure without the need for a traditional, separate phosphoric acid etch procedure. Its composition is such that it provides an in situ etch. The F2000 compomer primer/adhesive is not indicated for bonding other restorative materials to tooth structure. The product is contained in a unique delivery device called the 3M Clicker dispenser.

The Clicker dispenser is similar in construction to a double barreled syringe. Its side-by-side cartridges contain the two components of the compomer primer/adhesive. When actuated by depressing its lever, the device simultaneously and precisely dispenses a drop of each component. The Clicker dispenser is convenient and easy to use and it minimizes skin contact with the primer/adhesive liquids. It is less messy and stays cleaner through use than typical adhesive bottles. The dispenser incorporates a gauge that indicates the number of compomer primer/adhesive applications remaining in the dispenser. When full, the Clicker dispenser contains about 80 compomer primer/adhesive applications.

The F2000 compomer restorative can also be bonded to tooth structure with a 3M dental adhesive system such as the 3M™ Single Bond dental adhesive system or the 3M™ Scotchbond™ Multi-Purpose dental adhesive system. With these adhesive systems, a traditional phosphoric acid etch of the dentin and enamel is essential for adequate bonding.

Indications for Use

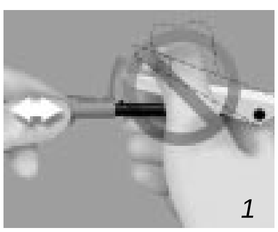
The 3M™ F2000 compomer restorative system is indicated for the following types of restorations.

- Class V cavities and cervical erosion/abrasion lesions
- Root caries lesions
- Class I and Class II cavities in primary teeth
- Class III cavities
- Class II laminate or open sandwich technique
- Temporary repair of fractured teeth
- Core buildup where approximately half the coronal tooth structure is remaining to provide support for the crown

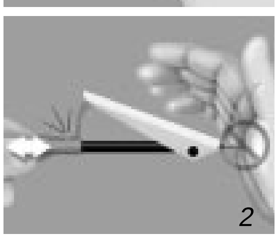
Basic Techniques

The basic procedures for using the 3M F2000 compomer restorative systems are presented here.

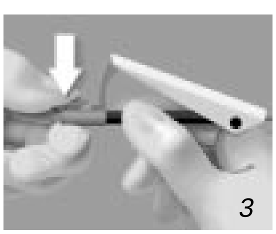
3M™ Clicker™ Dispenser Operation



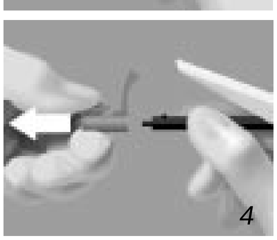
Precautions
- Do not depress the dispenser lever during cap removal and/or replacement.



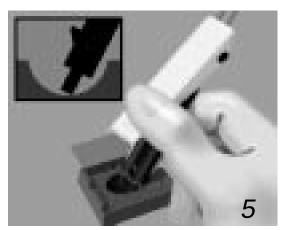
- Do not advance the dispenser plunger during cap removal and/or replacement.



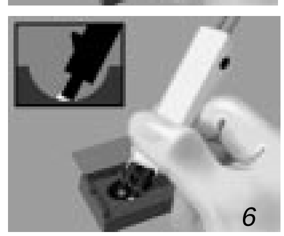
Operation
Remove Cap:
- Press and hold cap lever to unlock cap.



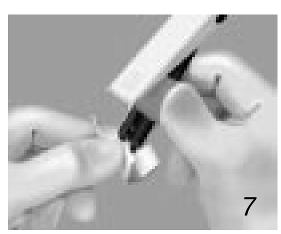
- Slide cap off dispenser.



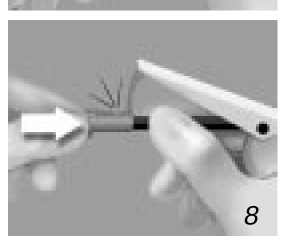
Dispense:
- Touch cartridge tips to bottom of well.
  Contact of the tips with the well bottom is critical to assure proper dispensing.



- Fully depress lever to dispense material from each side of cartridge into well.
- Release lever.
- Remove dispenser from well.



Clean:
- Wipe the cartridge tips with an alcohol-dampened gauze.



Replace Cap:
- Hold the sides of the cartridge and slide cap into place until securely latched as indicated by an audible click.

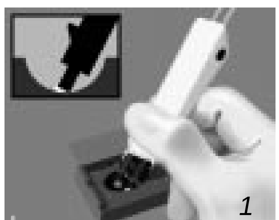
Direct Compomer Restoration:
3M™ F2000 Compomer Restorative with F2000 Compomer Primer/Adhesive in the 3M™ Clicker™ Dispenser

Indications:

- Class V cavities and cervical erosion/abrasion lesions
- Root caries lesions
- Class III cavities
- Class 1 and II cavities in primary teeth
- Temporary repair of fractured teeth

Preparation:

- Select shade using shade guide.
- Isolate the tooth.
- Remove caries.
- If no preparation is made, clean surfaces with pumice slurry.

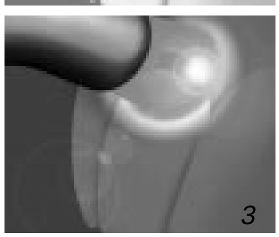


Dispense:

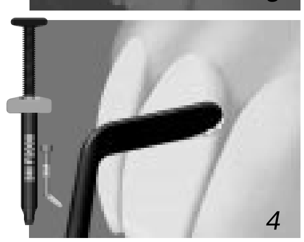
- Dispense the compomer primer/ adhesive into the mixing well.
- Using an applicator brush, mix solution in the well.

Prime/Bond:

- Generously apply compomer primer/adhesive to enamel and dentin.
- Wait 30 seconds. Keep surface wet for full time.
- Dry gently for 5-10 seconds.

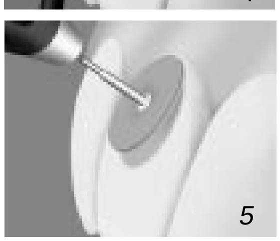


- Light cure the compomer primer/adhesive for 10 seconds.



Place Compomer:

- Place F2000 compomer restorative in increments.
- Light cure each increment for 40 seconds.



Finish/Polish:

- Use the 3M™ Sof-Lex™ Finishing and Polishing System and 3M™ Sof-Lex™ Strips for finishing and polishing the restoration.

Direct Compomer Restoration:

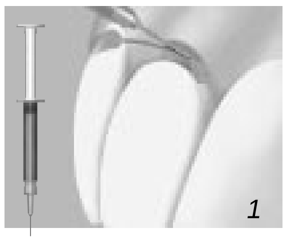
3M™ F2000 Compomer Restorative with 3M™ Single Bond Adhesive System

Indications:

- Class V cavities and cervical erosion/abrasion lesions
- Root caries lesions
- Class III cavities
- Class I and II cavities in primary teeth
- Temporary repair of fractured teeth

Preparation:

- Select shade using shade guide.
- Isolate the tooth.
- Remove caries.
- If no preparation is made, clean surfaces with pumice slurry.

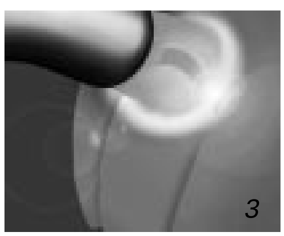


Etch:

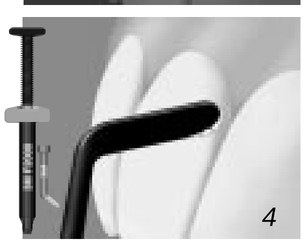
- Apply 3M™ Scotchbond™ etchant to enamel and dentin. Wait 15 seconds.
- Rinse.
- Blot excess water leaving tooth moist.*

Bond:

- Using a fully saturated brush tip for each coat, apply 2 consecutive coats of 3M™ Single Bond adhesive to enamel and dentin.
- Dry gently for 2-5 seconds.

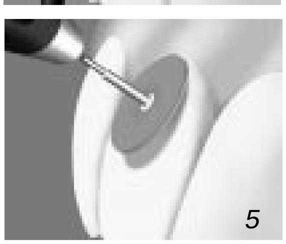


- Light cure the adhesive for 10 seconds.



Place compomer:

- Place F2000 compomer restorative in increments.
- Light cure each increment for 40 seconds.



Finish/Polish:

- Use the 3M™ Sof-Lex™ Finishing and Polishing System and 3M™ Sof-Lex™ Strips for finishing and polishing the restoration.

* Note: A 3M mini-sponge (No. 7522S) or a moist cotton pellet may be used for blotting. Be careful to avoid rubbing the tooth surface when blotting.

The following Table 1 is a summary comparison of the steps and approximate times required for bonding F2000 compomer restorative with its major bonding systems. Note that both techniques are relatively rapid. While bonding with the Single Bond adhesive system requires more steps due to the etching procedure, these steps are very familiar to the dental team.

Table 1. Materials and Techniques for Bonding F2000 Compomer. Comparison of Steps and approximate Time (seconds)

	3M™ F2000 Compomer Primer/Adhesive	3M™ Single Bond Adhesive System
Apply etchant	—	5
Apply primer/adhesive	5	—
Wait	30	15
Rinse	—	10
Dry	5–10	5
Apply adhesive	—	15
Dry	—	2–5
Light cure	10	10
Approximate time	*50–55*	*62–65*

Composition

3M™ F2000 Compomer Restorative

Listed below are the components of the F2000 compomer restorative and briefly, their function.

Component	Function
FAS glass	Filler Source of fluoride for long term fluoride release
Colloidal silica	Dispersing agent
CDMA oligomer (dimethacrylate functional oligomer derived from citric acid)	Acidic hydrophilic matrix former
GDMA (hydroxypropylene dimethacrylate, commonly known as glyceryl dimethacrylate)	CDMA diluent Hydrophilic comonomer
High molecular weight, hydrophilic polymer	Rheology[1] modifier Transports water and fluoride
CPQ/amine	Photoinitiator system

[1]Rheology is an intrinsic property of a material that defines its flow and handling characteristics.

The composition of the F2000 compomer restorative while different from that of Vitremer™ core buildup/restorative also has similarities. The FAS glass used in the F2000 compomer restorative is the same as that used in the Vitremer product. It has an average particle size of about 3 microns and a maximum size of about 10 microns. The filler size distribution and the very small amount of colloidal silica added with the filler contribute to the excellent handling of the paste. The filler loading is about 84% by weight.

The remaining ingredients listed above comprise the resin portion of the compomer restorative. The CDMA oligomer is similar in composition and function to the Vitrebond copolymer, a methacrylated polycarboxylic acid used in the Vitrebond™ liner/base, Vitremer restorative and some 3M adhesive products. Compared to the Vitrebond copolymer, it is a lower molecular weight material and has a greater ratio of methacrylate groups to carboxyl groups. This allows greater cross-linking of the resin matrix. GDMA (hydroxypropylene dimethacrylate) is chemically and functionally similar to HEMA (hydroxyethyl methacrylate) used in 3M glass ionomer and adhesive products. Like HEMA, it has a hydroxyl functionality which makes it hydrophilic. It acts as a diluent for the CDMA and copolymerizes with the oligomer. The high molecular weight, hydrophilic polymer is an essential and unique ingredient in the F2000 compomer formulation. It rapidly takes-up a controlled amount of fluid from the oral cavity which facilitates the transport of fluoride. Because it is a large and flexible polymer, it impacts the rheology of the paste and contributes to its excellent handling characteristics. An initiator system similar to that used in resin composite products which allows curing by light exposure is also included in the compomer restorative.

3M™ F2000 Compomer Primer/Adhesive

Listed below are the ingredients in the F2000 compomer primer/adhesive.

Side A	Side B
HEMA (2-hydroxyethyl methacrylate)	Maleic acid
Vitrebond copolymer (methacrylated polycarboxylic acids)	Water
Water	
Ethanol	
Photoinitiator	

The F2000 compomer primer/adhesive is an acidic, hydrophilic, polymerizable material highly compatible with dentinal and enamel surfaces. Sides A and B are kept separated until clinical use for stability of the system. However it is not a dual-cure material and must be exposed to a dental light source for curing. When the two parts are combined from the 3M™ Clicker™ dispenser, the solution that results is essentially the combination of the commercial product, 3M™ Vitremer™ Primer with maleic acid at about 2.5 weight percent. Its pH is 1.9–2.

3M™ Single Bond Dental Adhesive System

The Single Bond dental adhesive system includes 3M™ Scotchbond™ etchant and the Single Bond adhesive. Scotchbond etchant is a 35 weight percent phosphoric acid gel. It has a pH of about 0.6. Its purpose is to etch dentin and enamel.

Single Bond adhesive is a one bottle adhesive containing ethanol, HEMA, BisGMA, other dimethacrylate resins, methacrylate-modified polycarboxylic acid, a small amount of water and a novel photoinitiator system. Additional information on the adhesive system can be found in the 3M Single Bond dental adhesive system technical product profile.

Effect of 3M™ F2000 Compomer Primer/Adhesive on Enamel and Dentin

The effect of F2000 compomer primer/adhesive on enamel and dentin was investigated at the Minnesota Dental Research Center for Biomaterials and Biomechanics (MDRCBB) of the University of Minnesota under the direction of Dr. W. H. Douglas. Human enamel was ground and polished with silicon carbide paper. For group 1, phosphoric acid gel was applied for 15 seconds and then washed for 30 seconds. For group 2, F2000 compomer primer/adhesive was applied for 15 seconds and washed for 30 seconds. Figures 1 and 2 are photos of scanning electron micrographs of the phosphoric acid and F2000 compomer primer/adhesive treated enamel respectively. A typical etch pattern is seen with both materials. The etch resulting from the F2000 compomer primer/adhesive appears somewhat shallower than that from the phosphoric acid treatment. The F2000 primer/adhesive contains a methacrylated polycarboxylic acid, the Vitrebond copolymer, which is strongly absorbed on the enamel hydroxyapatite. This has been shown by Fourier transform infrared (FT-IR) analysis. This may be a reason for the apparent shallower etch pattern with the material.

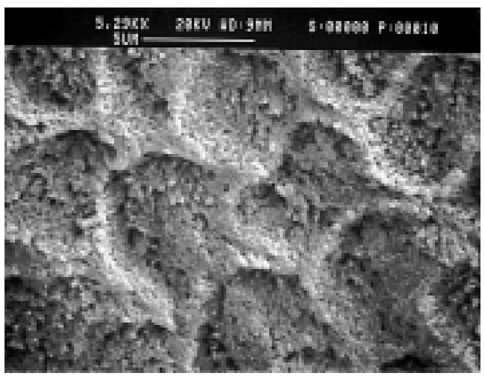


Figure 1.

Figure 2.

From the SEM studies, it can be concluded that the mechanism by which F2000 compomer primer/adhesive bonds to enamel is to first etch the substrate, wet and penetrate the etched surface and polymerize forming a mechanical lock with the enamel. The FT-IR study also suggests that there is a strong inherent absorption of the methacrylated polycarboxylic acid on the calcium hydroxyapatite. The subsequently placed compomer restorative then chemically bonds with the compatible compomer primer/adhesive.

For the investigation on dentin, the groups were the same as those for the enamel evaluation. Figure 3 is a photo of a scanning electron micrograph of a dentin surface after treatment with the F2000 compomer primer/adhesive. Note that the tubules are partially opened though not to the extent as typically seen with phosphoric acid treatment. To determine if F2000 compomer primer/adhesive penetrated the partially occluded tubules, F2000 compomer restorative was bonded to dentin with the F2000 compomer primer/adhesive. The dentin was then dissolved away. Figure 4 shows the resin tags that formed in the dentinal tubules and confirms the penetration of the compomer primer/adhesive.

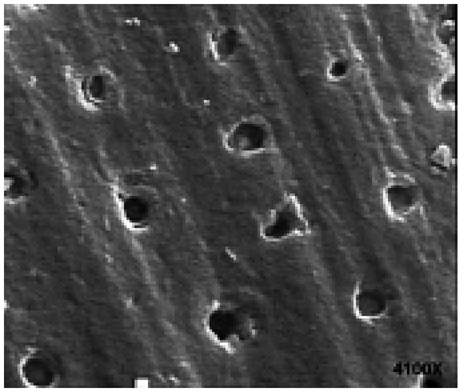


Figure 3.

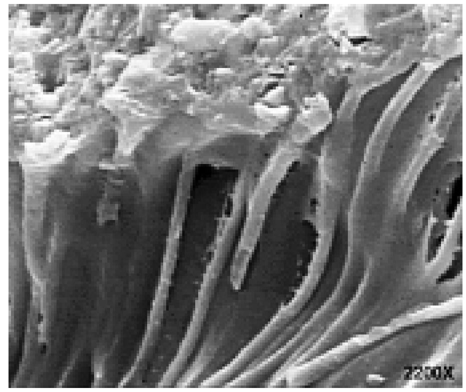


Figure 4.

Dr. F. Garcia-Godoy, Global Research Consultants, San Antonio, Texas, investigated the formation of a hybrid layer at the dentin interface with the 3M™ Single Bond adhesive system and with the F2000 compomer primer/adhesive. For the Group 1 samples, teeth were restored using F2000 compomer restorative bonded with the Single Bond adhesive system in accordance with product instructions. For Group 2, the F2000 compomer primer/adhesive was applied followed by the F2000 compomer restorative. Specimens were sectioned and examined using scanning electron microscopy. Dr. Garcia-Godoy concluded from his study that both groups showed hybrid layer and resin tag formation into dentin. He further concluded that there were no differences in thickness of the hybrid layers of the two groups. Figure 5 is a photo of a scanning electron micrograph representative of the Group 2 specimens, those restored using the F2000 primer/adhesive. Note the resin tags in the dentinal tubules to the left and the hybrid layer to the right.

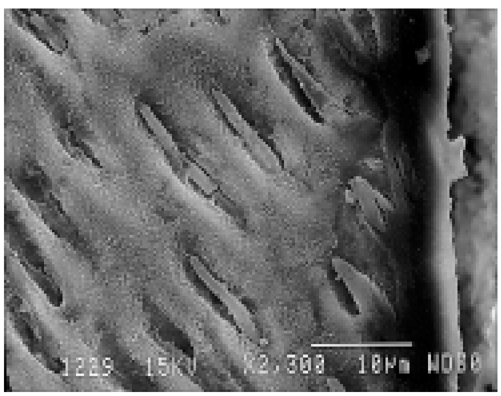


Figure 5.

The mechanism by which F2000 compomer primer/adhesive bonds to dentin is to etch the dentin and partially open the dentinal tubules, form a hybrid interface by interpenetration of the etched dentin and polymerization of the compomer primer/adhesive. As with enamel bonding, the subsequently placed compomer restorative chemically bonds with the compomer primer/adhesive.

Application of low pH materials to dentin has been a subject of study by a number of researchers. Douglas et al., studied the effect of Scotchprep primer on dentin by measuring pH. This material contains the same concentration of maleic acid as the F2000 compomer primer/adhesive. When first applied to dentin, the Scotchprep primer had a pH of 1.6–2.3. After drying and re-wetting to allow measurement, the residual pH was 4.5. This was equivalent to the residual pH following phosphoric acid treatment. It was concluded that dentin rapidly buffered the acidity of the primer. Chan and Jensen (1986), Wang and Hume (1988) and Ishikawa et al., (1989) also documented the excellent buffering capacity of dentin. The ability of dentin to buffer acids thus protects pulpal tissue from the effects of the acids. Hence the use of the F2000 compomer primer/adhesive is not expected to have any deleterious effect on dentin and subsequently, on pulpal tissue.

Evaluations

Numerous evaluations of F2000 compomer restorative prototype pastes, primer/adhesive options and bonding techniques were evaluated *in vitro* with practicing dentists throughout Europe and in North America. Prototype pastes were evaluated for handling in Class V cavities in dental mannequins heated to human oral cavity temperature of about 34°C. Without identification of brand name, the market-leading compomer product, Dyract™, was also assessed for handling in these evaluations. In one evaluation conducted in three European countries, 90% of the seventy respondents preferred the handling of a F2000 compomer restorative prototype paste over that of Dyract when tested blind. In another study conducted in Germany, 85% of the evaluators preferred the handling of the F2000 compomer restorative prototype paste over that of Dyract. And in a Canadian study, the handling of the F2000 compomer restorative prototype paste was preferred over that of Dyract by 82% of the participants. Additional evaluations conducted in the United States showed similar findings. Respondents stated most frequently that they liked the handling of the F2000 compomer restorative prototype paste because it was not sticky, did not stick to the placement instrument, was easy to shape, did not slump and was easy to apply and adapt to the cavity.

Techniques for bonding a compomer restorative to tooth structure were also addressed in the evaluations. Not surprisingly, it was found that techniques requiring the fewest steps such as those having one light cure step rather than two were preferred by the respondents. The compomer primer/adhesive in the 3M™ Clicker™ dispenser was favorably received because of the elimination of an extra acid etching step and the convenience in dispensing the primer/adhesive.

About 100 dental auxiliaries/dental nurses in the US, Sweden, France, Germany and the UK used the Clicker dispenser in a simulated clinical evaluation to assess its performance and compare it to other dental adhesive systems being used by them at the time. Both the Clicker dispenser and the current dental adhesive system were rated for ease of set-up, ease of dispensing, ease of recapping, cleanliness, ease of disinfecting and overall ease of use. It was found that for all features rated, the overall ratings for the Clicker dispenser were better than those for the respondent's adhesive systems to which the dispenser was compared. Respondents stated that they liked the Clicker dispenser because it was an easy system–easy to use, easy to store, easy to clean and easy to set-up. It was also seen as providing precise dosing of the primer/adhesive and less messy/more clean than adhesive vials. The Clicker dispenser performed well in the evaluations and was preferred by a majority of the respondents over the adhesive systems they were using at the time of the studies.

A clinical assessment of the F2000 compomer primer/adhesive in the Clicker dispenser and the F2000 compomer restorative was conducted under the direction of Professor F. J. T. Burke, University of Glasgow Dental School, Scotland. Ten dentists from Professor Burke's PREP Panel, a group of practitioners who clinically evaluate dental materials, participated in the study. Through the course of the evaluation, they placed a total of 236 restorations of which 125 were Class V and 87 Class III restorations

The Clicker dispenser was rated very highly by the PREP Panel. On a scale of 1 to 5 where 5 was convenient and 1 inconvenient, the dispenser had a near perfect mean score of 4.9. Many of the F2000 compomer restorative paste features also were rated extremely well. The viscosity of the F2000 compomer restorative paste received a mean score of 2.9 where 3 would be perfect as 5 was too viscous and 1 was too thin. When compared with the glass ionomer normally used, the F2000 compomer restorative was judged to have better handling by eight of the respondents. And overall, ninety percent of the evaluators felt that no changes were essential to the acceptability of the compomer restorative.

Properties

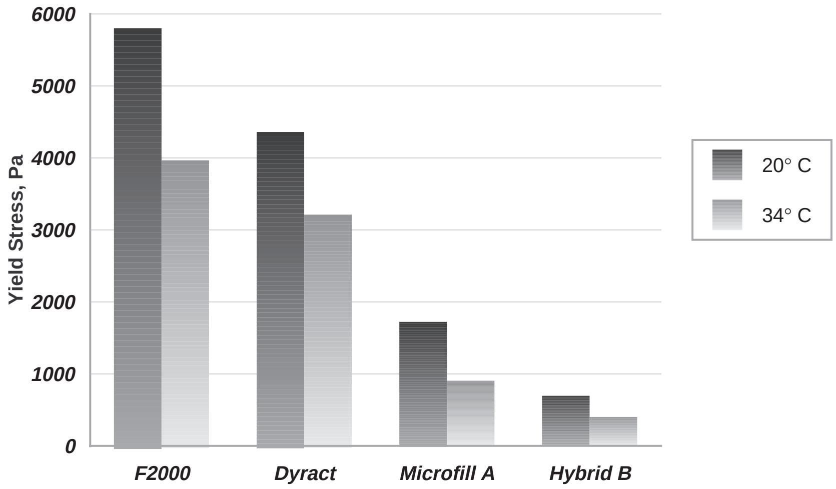
Handling

The handling of a dental restorative impacts how easy or not-so-easy the material is for a dentist to use clinically. One of the reasons cited most often for why a compomer product is used is its handling. “It has good handling, it is easy to use” are comments often heard from compomer-using dentists. In general, the compomer products have more internal structure and attractive molecular forces than composites which positively affect the handling characteristics of these materials. Use of the hydrophilic polymer in the F2000 compomer restorative provides additional beneficial rheological (handling) properties because of its high molecular weight and its favorable water absorption and transmission characteristics.

Handling is a complex characteristic of dental restoratives made up of multiple, interacting features including thickness, stickiness and flow. No single measure can define the handling of a restorative paste though certain tests can define certain features. Yield stress is one of these. It is a laboratory measure that can help define the slump of a restorative paste and differentiate restorative products.

Yield stress is the minimum stress required to cause a material to flow. The higher the yield stress, the less the material will slump. Figure 6 shows the yield stress measurements for 3M™ F2000 compomer restorative, Dyract™, a typical microfill and a typical hybrid composite at approximate room and mouth temperatures. The yield stress of F2000 compomer restorative is higher than that of Dyract and the composite materials. The yield stress of the compomers is higher than the composites shown. While there may be exceptions to this latter finding, it was the usual case for the materials studied. The data also support the positive field evaluation findings that F2000 compomer restorative held its shape and did not slump when evaluated in Class V cavities. It too supports the general comments of dentists that compomers handle better than composites.

Figure 6.
Yield Stress



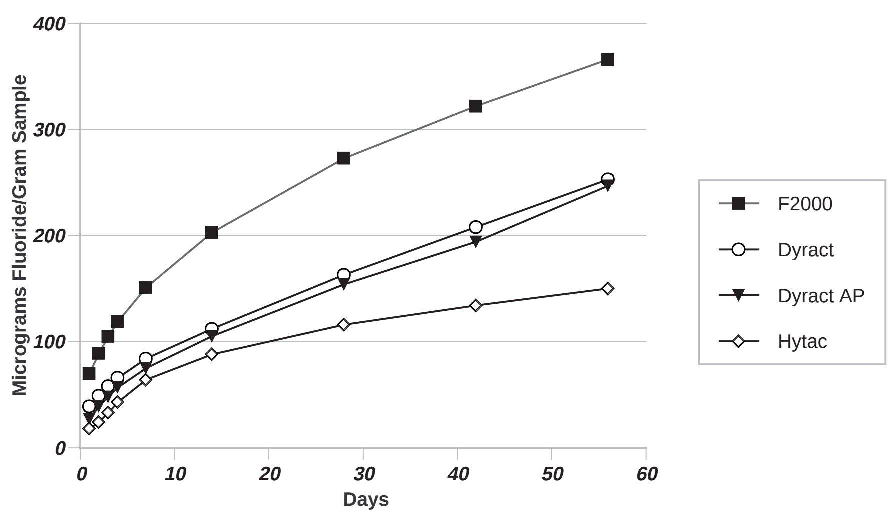
Fluoride Release

In the past in the 3M Dental Products laboratory, the release of fluoride from products such as Vitrebond™ liner/base and Vitremer™ core buildup/restorative was measured in a phosphate buffer solution at physiological pH. Samples of the test materials were prepared, placed in the buffer solution and the solution measured for fluoride concentration at various time periods using a fluoride ion-specific electrode. The test specimens were not removed from the buffer solution though the solution was replenished as needed to maintain a relatively constant volume.

More recently, a method for measuring fluoride released into deionized water, a test method used more commonly among researchers around the world, has been adopted in the 3M Dental Products laboratory. Fluoride released from F2000 compomer restorative, competitive compomers and glass ionomer products has been measured by this newer method. In this case, test specimens are made in 20 mm diameter by 1 mm thick molds and cured. Each specimen is then placed into a jar containing 25 ml of deionized water and stored in a 37° C oven for a specified time period. At the time of fluoride measurement, an aliquot of the water containing the test specimen is taken, diluted 1:1 with TISAB (Total Ionic Strength Adjustment Buffer-Orion Research) and parts per million (ppm) of fluoride are measured directly using a fluoride ion-specific electrode (Orion Fluoride Combination Electrode). The deionized water that remains in the specimen jar is discarded, 25 ml of fresh deionized water is added and the test specimen is returned to the jar which is again stored in a 37° C oven. The process is repeated for each time interval of testing. The fluoride released by the test specimen is reported as cumulative micrograms of fluoride per weight of specimen or can be reported per area of specimen. The advantage of this test method is that the test specimen is exposed to fresh solution at greater frequency which may allow more accurate release of fluoride and may better represent the clinical situation.

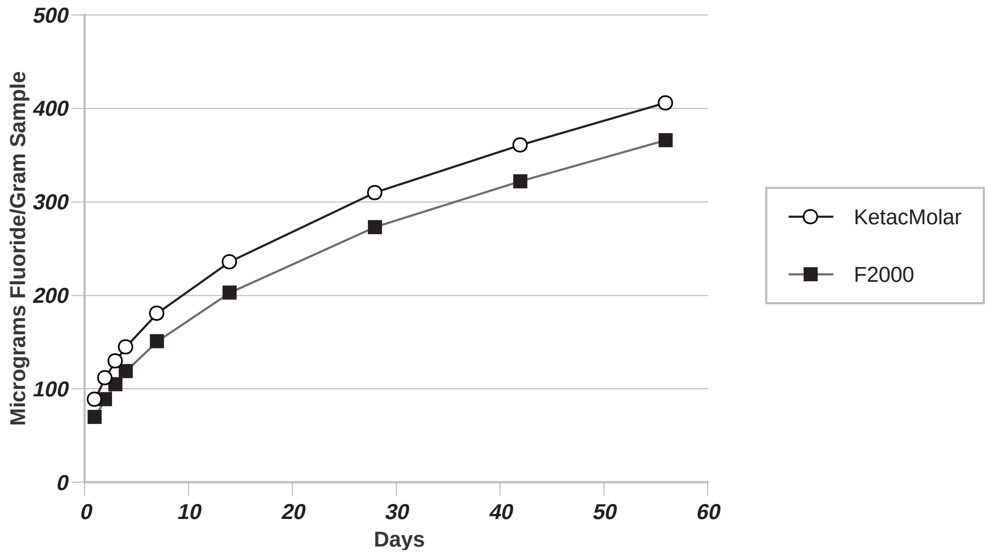
Shown as Figure 7 is the cumulative fluoride released from 3M™ F2000 compomer restorative in comparison with other compomer products, namely Dyract™, Dyract® AP and Hytac® Aplitip®. It can be seen that the F2000 compomer restorative exhibited a greater release of fluoride than did the other materials for the period studied.

Figure 7. Cumulative Fluoride Released. Compomer Products



It can be said that the compomer products in general have a lower fluoride release than that of the conventional and resin-modified glass ionomers. Figure 8 illustrates this point as it compares the fluoride released from F2000 compomer restorative and that from a conventional glass ionomer, Ketac® Molar. In this particular case, the fluoride released from these two different types of materials is relatively similar. It must be noted however, that the release of fluoride varies considerably among the glass ionomer products some releasing very high amounts and others releasing significantly lower amounts. Ketac® Molar has demonstrated a lower amount of fluoride release than Vitremer™ core buildup/restorative for example.

Figure 8. Cumulative Fluoride Released. Compomer and Glass Ionomer



Dr. F. Garcia-Godoy, Global Research Consultants, San Antonio, Texas, also studied short-term fluoride release. The materials included in his study were Vitremer core buildup/restorative, a 3M experimental compomer EXL 343 now known as the F2000 compomer restorative and Dyract™. The amount of fluoride released from the test materials into neutral deionized water and into pH 4.5 acidic medium was determined and reported as parts per million (ppm). A pH value of 4.5 is of particular interest because it is representative of the local acidity in a carious condition which is lower than the local pH in the healthy condition. Figure 9 shows the fluoride released from all the test materials in the acidic medium. Figure 10 compares the fluoride released from the EXL 343 (F2000 compomer restorative) into both test media studied. It is interesting to see that the compomer product released more fluoride in the acidic solution than in the neutral deionized water. The glass ionomer material was essentially unaffected by the pH of the test media as can be seen by Figure 11.

Figure 9. Cumulative Fluoride Released in Acidic Medium

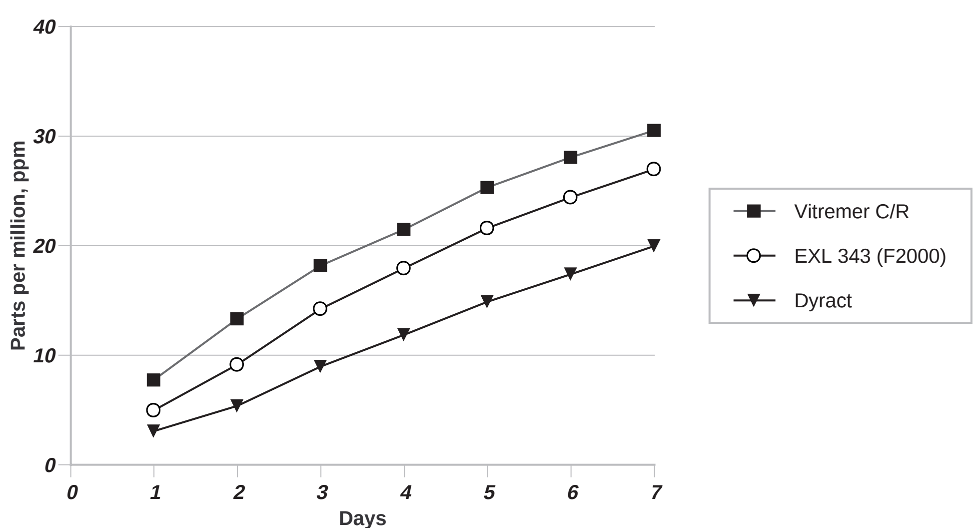


Figure 10.
Cumulative Fluoride Released from EXL 343 (F2000)

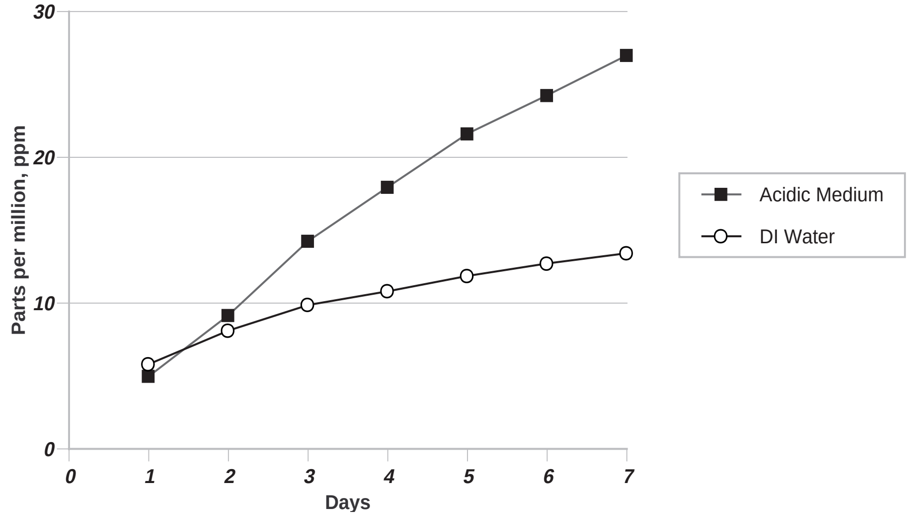
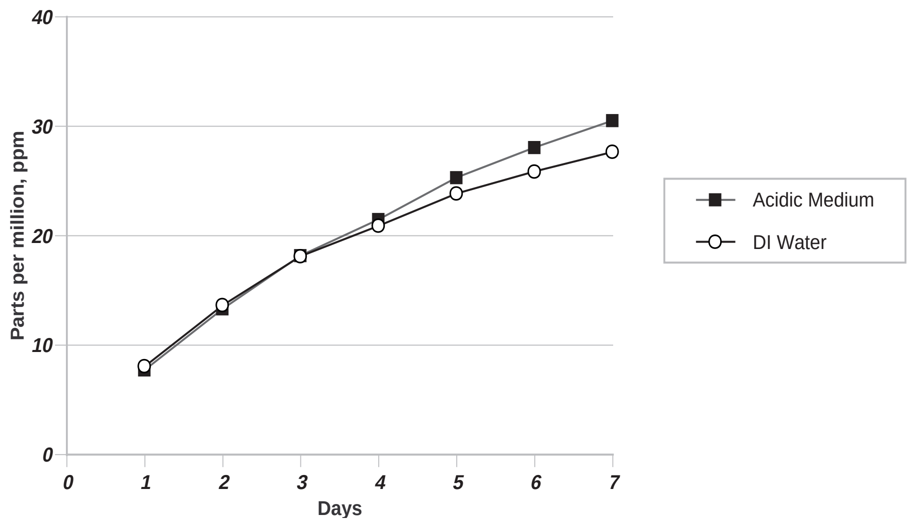
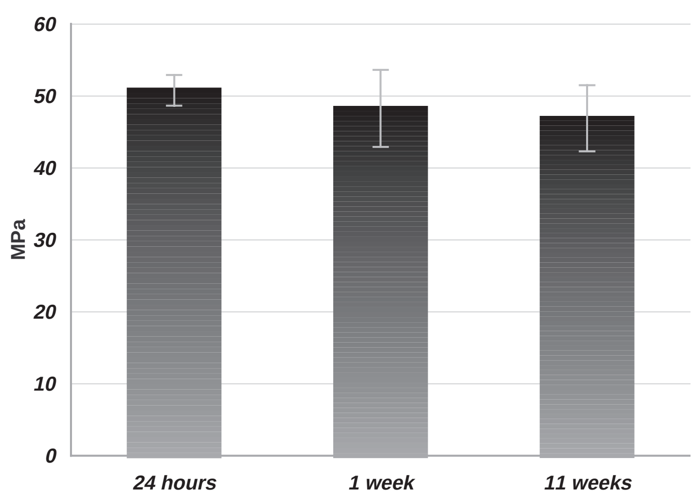


Figure 11.
Cumulative Fluoride Released from Vitremer Core Buildup/Restorative



To determine if fluoride release over a sustained period weakens F2000 compomer restorative, one of its physical properties was measured over time. Test specimens were made, stored in water in a 37° C oven to allow fluoride release, removed and tested at certain time intervals. Results are shown as Figure 12. It can be seen that there was no significant change in the diametral tensile strength of the F2000 compomer restorative over the eleven week study period. Fluoride release did not adversely affect the integrity of the material.

Figure 12.
F2000 Compomer Restorative. Diametral Tensile Strength



In Vitro Caries Inhibition

Inhibition to *in vitro* artificially induced caries at dentin margins was investigated to assess the effect of fluoride release. The investigation was conducted by Tantibirojn and Douglas at the MDRCBB of the University of Minnesota. Bovine roots were cut into sections and cavities were prepared in them. The cavities were filled with 3M™ F2000 compomer restorative bonded with 3M™ F2000 compomer primer/adhesive, F2000 compomer restorative bonded with 3M™ Single Bond adhesive system, Dyract™ bonded with Prime & Bond™, Vitremer™ core buildup/restorative placed with Vitremer™ primer to serve as a positive control and P-50 restorative to serve as a negative control. After polishing the restorations, the teeth were sealed with nail varnish leaving just a window around the restoration which would be subjected to demineralization. Each specimen was immersed in acid gel of pH 5.1 at 37° C for 3 weeks. After removal from the acid, each specimen was cut into thin slices and hand polished to about a 300 micron thickness. Microradiographs were taken of the specimens and viewed to determine the response to the acid demineralization. The following Table 2 summarizes the findings.

Table 2. Inhibition to In Vitro Artificial Caries at Dentin Margin

Material	% of Samples Showing Inhibition	% of Samples Showing Wall Lesions
P-50	0	100
Dyract/Prime & Bond	12	25
F2000 Compomer/ Single Bond Adhesive System	25	12
F2000 Compomer/ F2000 Compomer Primer/Adhesive	75	0
Vitremer/Vitremer Primer	100	0

Photos of representative microradiographs of the test specimens are shown as the following figures. Figure 13 is representative of the P-50 specimens. As was expected and as indicated in the above table, no inhibition to the artificially induced caries was seen in any of the specimens. All the specimens showed wall lesions. Figure 14 is representative of the specimens restored with Dyract/Prime & Bond showing no inhibition to the demineralization protocol. In this sample, a slight wall lesion is also evident. Figure 15 is representative of a specimen restored with F2000 compomer and the Single Bond adhesive system that exhibited inhibition to the artificially induced caries and showed no wall lesion. Figure 16 is illustrative of the specimens restored with F2000 compomer and the F2000 compomer primer/adhesive. A distinct zone of inhibition between the tooth/restoration interface and the lesion can be seen. Figure 17 is representative of the specimens restored with Vitremer core buildup/restorative. The lesion resulting from the demineralization is relatively shallow and as with the majority of specimens restored with F2000 compomer/F2000 compomer primer/adhesive, a distinct inhibition zone is evident.

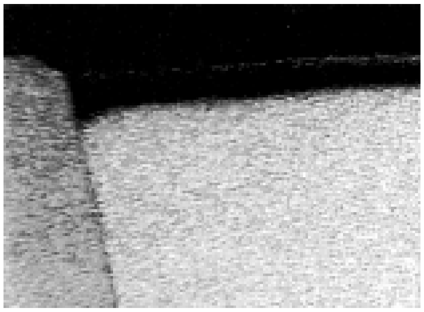


Figure 13.

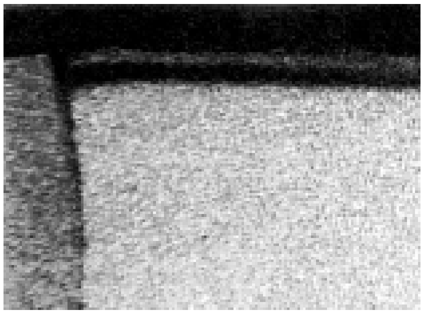


Figure 14.

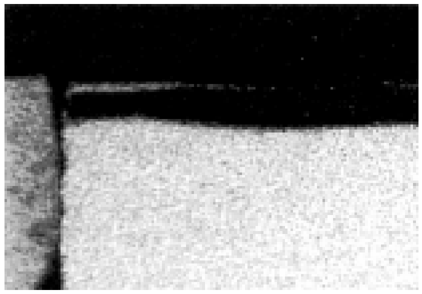


Figure 15.

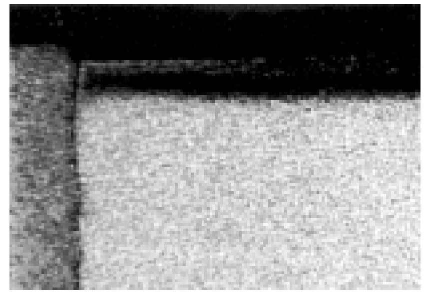


Figure 16.

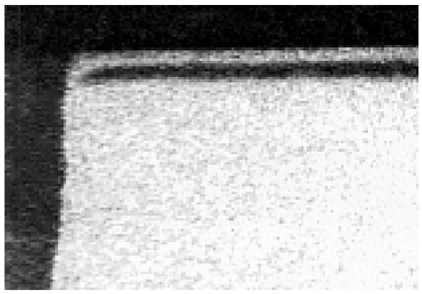


Figure 17.

Adhesion

This section will include discussion and results of *in vitro* bond strength testing. These tests were conducted using teeth first potted in methyl methacrylate and then ground and polished to expose enamel or dentin. A cylinder of test material formed by a Teflon mold 5 mm in diameter and 2 mm in height, was then bonded to the tooth surface. After bonding and curing the sample, specimens were placed in water at 37° C for 24 hours. Shear bond strength was determined using an Instron universal testing machine.

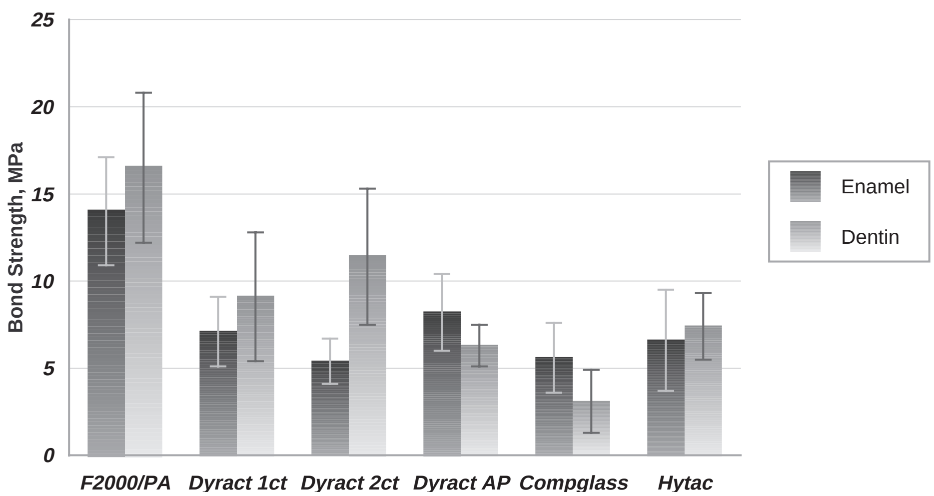
Unless otherwise noted, all materials were tested in accordance with manufacturer's instructions for clinical use, i.e. the adhesion samples were prepared with or without phosphoric acid etching, using the bonding agents relative to the number of applications, dwell times, cure times, etc., as indicated. As stated previously, 3M™ F2000 compomer restorative can be bonded to tooth structure with the 3M™ F2000 compomer primer/ adhesive or with a 3M dental adhesive system. Data will be presented for both types of adhesive systems. In some parts of the world, one coat of Prime & Bond™ 2.1 is indicated for bonding Dyract™ and in other parts, two coats are indicated by the manufacturer. Bond strengths were therefore determined using both techniques. Table 3 lists the restorative material tested, the adhesive product used for bonding the restorative material, the number of coats of the adhesive applied to the test substrate and the abbreviation used in subsequent Figures for the combinations of materials.

Table 3. Materials Used in Bond Testing and Abbreviations Used in Subsequent Figures

Compomer Product	Etch	Adhesive/Conditioner	Number of Coats	Abbreviation
F2000 compomer	No	F2000 Compomer Primer/Adhesive	1	F2000/PA
F2000 compomer	Yes	Single Bond Adhesive System	2	F2000/SB
F2000 compomer	Yes	Scotchbond™ Multi-purpose Adhesive System	—	F2000/SBMP
Dyract™	No	Prime & Bond™ 2.1	1	Dyract 1ct
Dyract	No	Prime & Bond 2.1	2	Dyract 2ct
Dyract® AP	No	Prime & Bond 2.1	2	DyractAP
Compoglass™	No	Compoglass SCA	2	Compglass
Hytac® Aplitip®	No	Hytac OSB	2	Hytac
Vitremer™ restorative	No	Vitremer Primer	—	Vitremer
Ketac® Molar	—	Ketac Conditioner	—	KetacM
Ketac Fil	—	Ketac Conditioner	—	KetacF

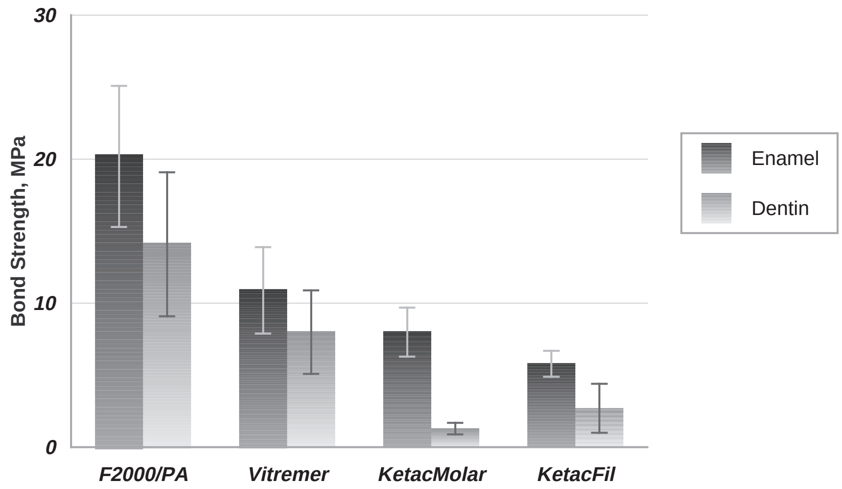
The bond of F2000 compomer restorative with F2000 compomer primer/adhesive measured approximately 14 MPa to enamel and 16.5 MPa to dentin. These values are higher than those of other compomer restorative systems as shown graphically by Figure 18.

Figure 18. Bond of F2000/PA and Other Compomer Systems



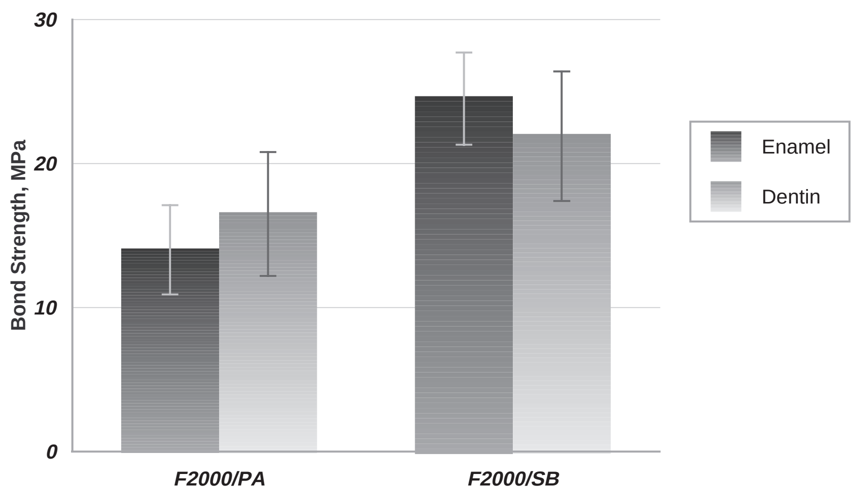
In another study, the bond of F2000 compomer with F2000 compomer primer/adhesive was compared with that of glass ionomer products. These results are illustrated as Figure 19. The bond of the compomer restorative system to both enamel and to dentin exceeded those of the glass ionomer products. It must be noted that while glass ionomers in general exhibit fairly low measured bond strength compared with other tooth colored restorative materials, they have demonstrated excellent clinical retention over time.

Figure 19.
Bond of F2000/PA.
Comparison with
Glass Ionomers



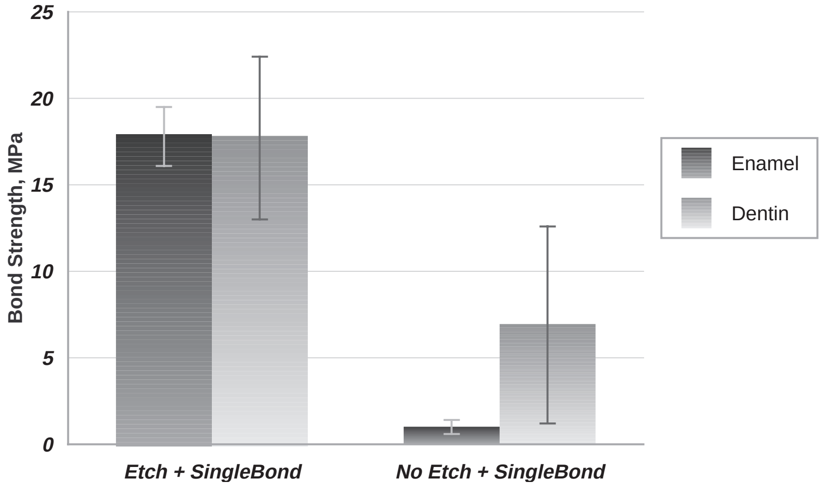
F2000 compomer restorative can also be bonded to tooth structure using a 3M dental adhesive system such as the 3M™ Single Bond adhesive system or the Scotchbond™ multi-purpose adhesive system. With these systems a phosphoric acid etch of enamel and dentin is required for adequate bonding. The bond strength of F2000 compomer restorative with the Single Bond adhesive system is about 25 MPa to enamel and about 22 MPa to dentin. These bond strength values are shown in Figure 20 in comparison with those measured with the F2000 compomer primer/adhesive.

Figure 20.
Bond of F2000
Compomer.
Comparison of
Adhesive Systems



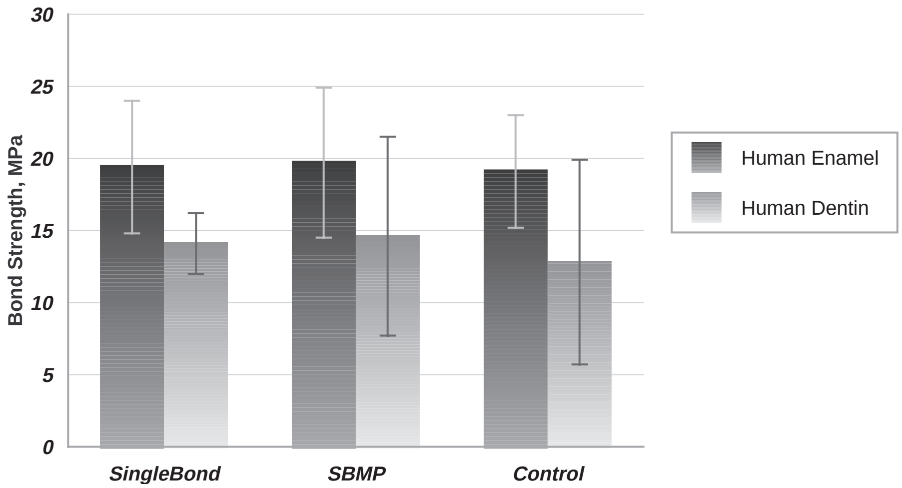
The effect of etching and not etching with the Single Bond adhesive was investigated and results are shown as Figure 21. An excellent bond was obtained to both enamel and dentin when the adhesive system was used as indicated with an etch. A very poor result was expected and was obtained when it was not. These data clearly demonstrate the importance of the acid etch procedure when bonding F2000 compomer restorative with Single Bond adhesive and other 3M dental adhesives where a separate etch is indicated.

Figure 21.
Bond of F2000.
Effect of Etching with
Single Bond Adhesive



The Scotchbond™ multi-purpose dental adhesive system can also be used to bond the F2000 compomer restorative. Laboratory bond testing conducted in the 3M Dental laboratory in France showed the adhesion values with the Scotchbond multi-purpose adhesive system to be equivalent to those with the Single Bond adhesive system. The bond strengths obtained with the two adhesive systems and the control system, Z100™ restorative bonded with the Scotchbond multi-purpose adhesive system, are shown in Figure 22.

Figure 22.
Bond of F2000
Compomer with 3M
Adhesive Systems



The effect of elevated humidity and temperature on the bond of F2000 compomer restorative with the Single Bond adhesive system was also studied in the French laboratories. Figure 23 shows the results of the study. While differences can be seen in the mean bond strengths at ambient conditions compared with those at simulated oral conditions, i.e. elevated humidity and temperature, the differences within the enamel values and within the dentin values are not statistically significant.

Figure 23.
Bond of F2000/SB.
Effect of Humidity and Temperature

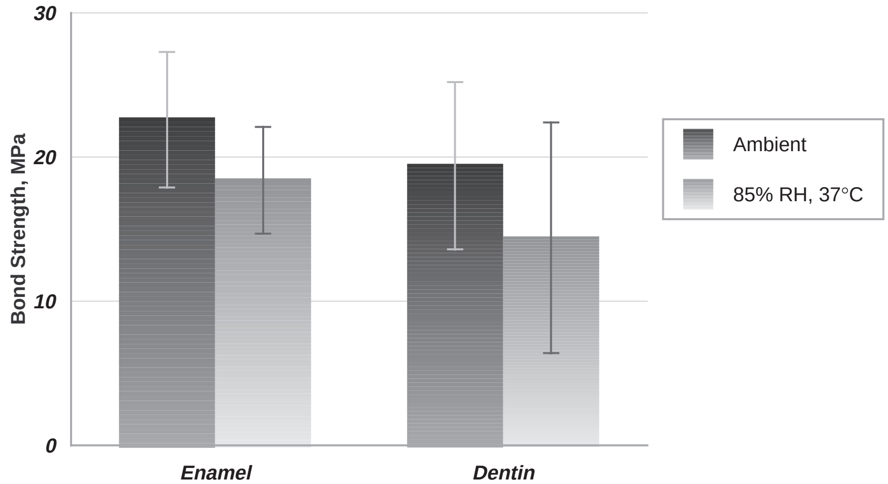
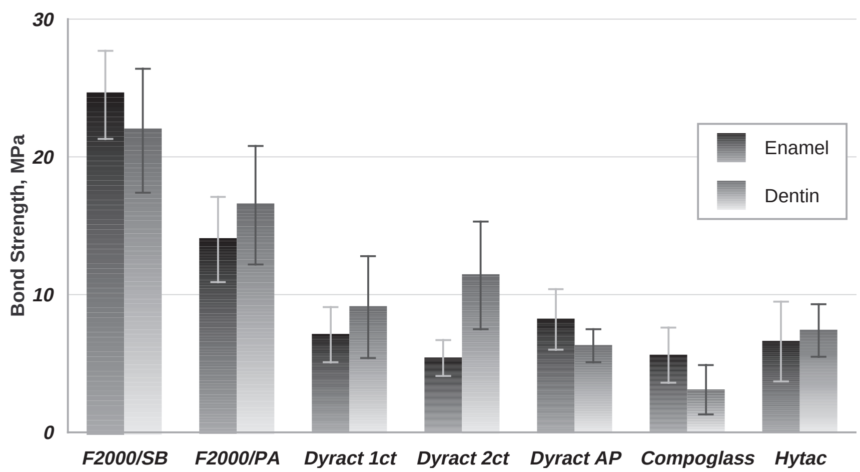


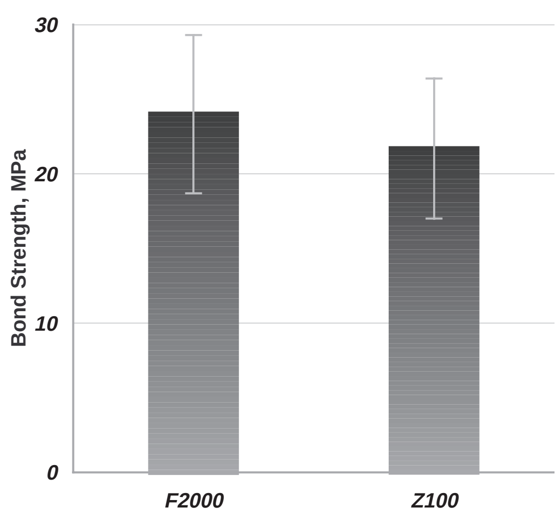
Figure 24 is presented to summarize the bond strengths of 3M™ F2000 compomer restorative with its major bonding systems and to compare these with the bond strengths of other compomer systems.

Figure 24.
Bond of F2000 Compomer Systems and Other Compomer Systems



The adhesion of materials to cured F2000 compomer restorative is important considering the clinical use of the product. In deep cavities, the compomer restorative should be placed in layers with each layer light cured separately. Bonding compomer to cured compomer is thus required. F2000 compomer restorative may also be used in a sandwich or laminate technique where a composite may be bonded over it. Figure 25 shows the excellent bond of F2000 compomer and Z100™ restorative to the cured compomer. With the latter material, a coating of Single Bond adhesive was applied to the cured F2000 compomer before Z100 restorative placement.

Figure 25.
Bond of Materials fo Cured F2000 Compomer

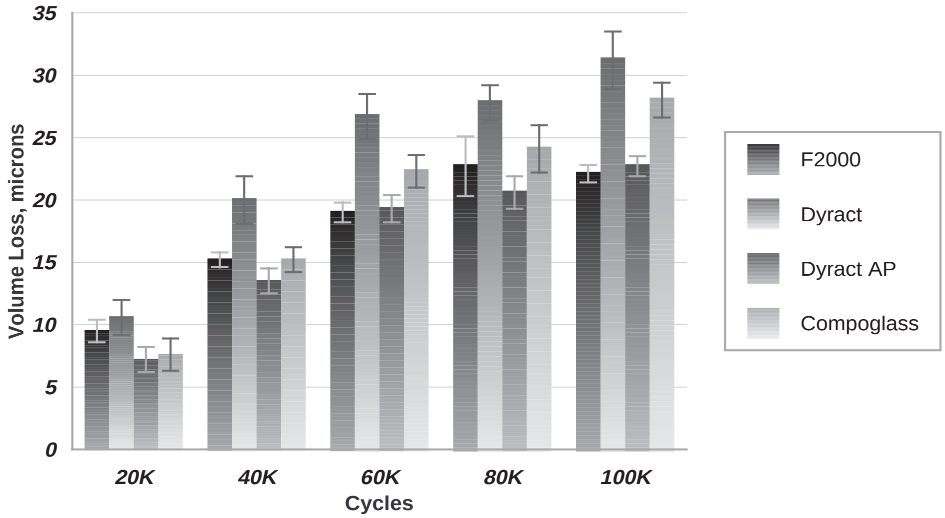


Wear Resistance

In vitro wear of the 3M™ F2000 compomer restorative was compared with a variety of materials in the ACTA wear machine, a three-body abrasion testing instrument. The machine has two motor-driven wheels that roll against each other in the presence of a third body abrasive material. One of the wheels accommodates the test materials and the other contacts it acting as an "antagonistic cusp." As the wheels rotate, the third body abrasive material is dragged between them creating three-body abrasion. Following wear cycles, volume loss of the test materials is measured by profilometry.

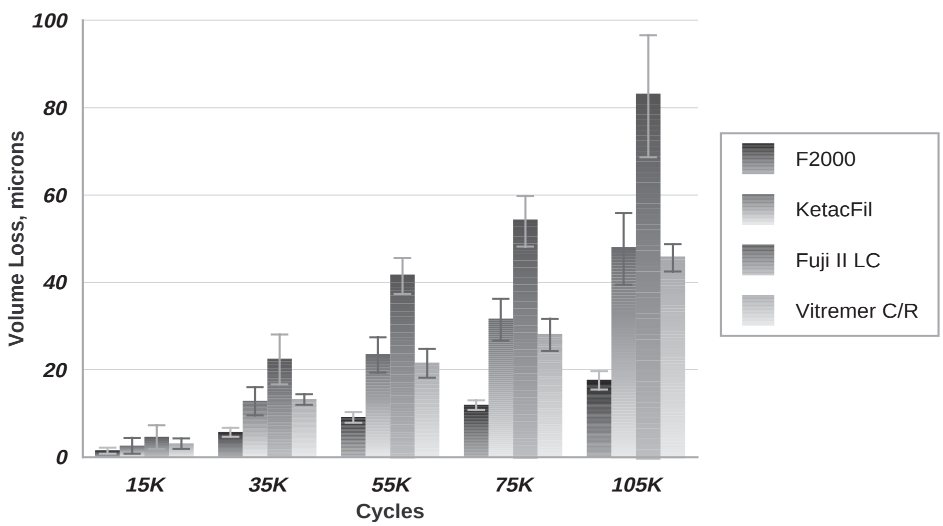
Figure 26 shows the cumulative volume loss in microns of F2000 compomer restorative and other compomer products. F2000 compomer restorative demonstrated lower volume loss or greater wear resistance than Dyract™ and Compoglass™ and wear resistance similar to Dyract® AP.

Figure 26. Cumulative Volume Loss/In Vitro Wear. Compomer Products



In another study, the in vitro wear of F2000 compomer restorative was compared with that of a conventional and two resin-modified glass ionomers. Results of this study are shown as Figure 27. The F2000 compomer restorative is significantly more wear resistant than the glass ionomer products studied.

Figure 27. Cumulative Volume Loss/In Vitro Wear. F2000 Compomer and Glass Ionomers.



Mechanical Properties

In general, the compomer products have higher mechanical properties than the resin-modified and conventional glass ionomers. Figures 28 and 29 compare the compressive and diametral tensile strengths respectively of F2000 compomer with these types of glass ionomer products.

Figure 28. Compressive Strength. F2000 Compomer and Glass Ionomers.

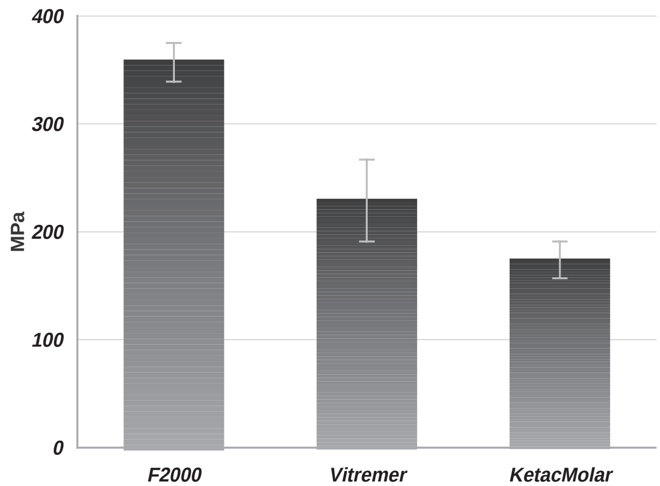
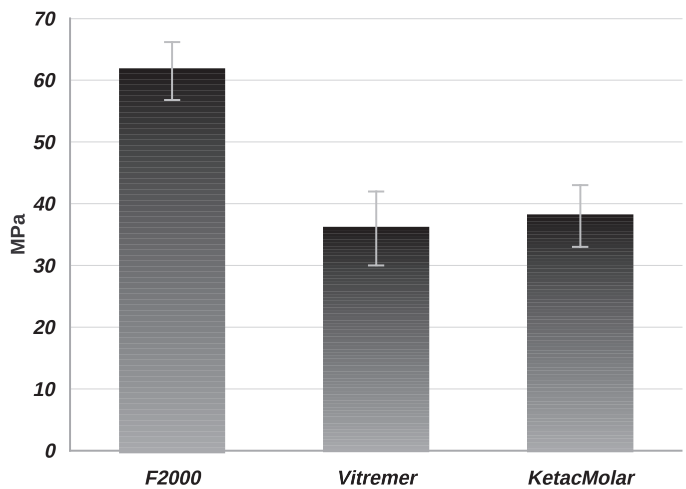


Figure 29. Diametral Tensile Strength. F2000 Compomer and Glass Ionomers



Figures 30 and 31 show the compressive and diametral tensile strengths respectively of 3M™ F2000 compomer restorative, other compomer products and a microfill restorative. It can be seen that the F2000 compomer restorative is somewhat stronger in compression than the other compomers and similar to that of the Silux Plus™ restorative. The diametral tensile strengths of the compomer restorative products are very high, comparable to that of microfill restoratives.

Figure 30.
Compressive
Strength.
Compomer Products

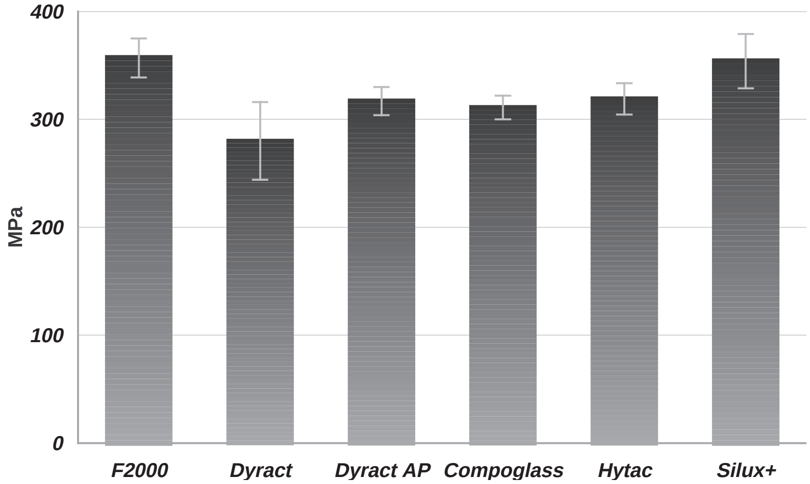
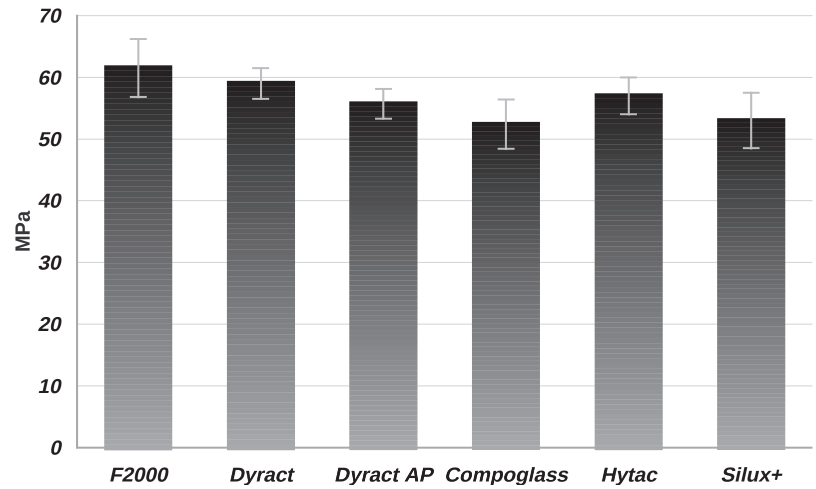


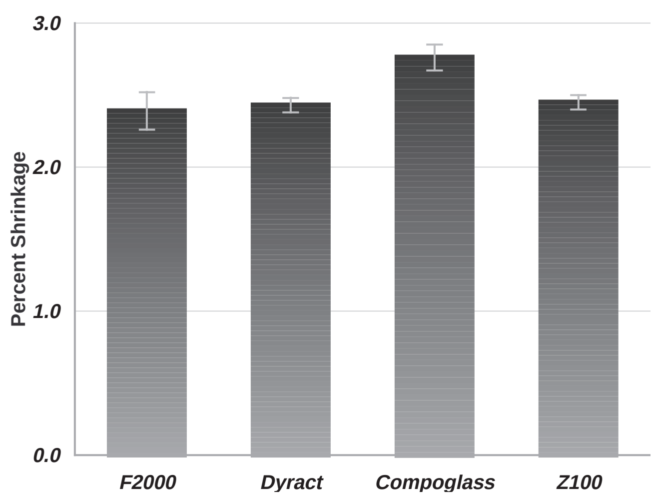
Figure 31.
Diametral Tensile
Strength.
Compomer Products



Shrinkage

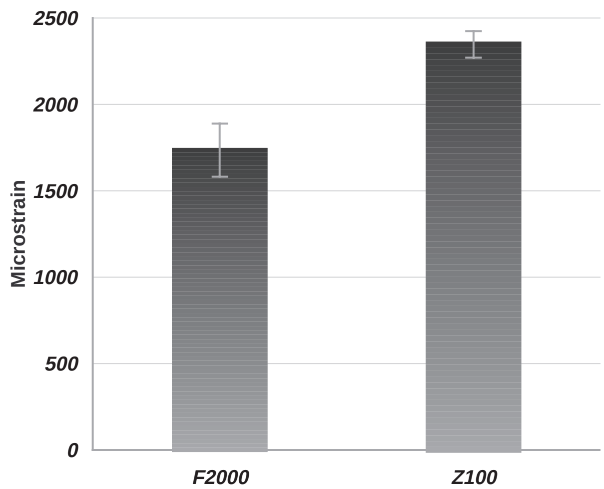
A method for determining the polymerization shrinkage of visible-light-cured materials has been described by Watts and Cash (1991). By this method, a disc-shaped test specimen is sandwiched between two glass plates and light cured through the lower rigid plate. The upper non-rigid plate is easily deflected by the polymerization shrinkage of the test material. Deflection is measured and recorded as a function of time. The percentage shrinkage is calculated from the data and is equivalent to volumetric shrinkage. The shrinkage of 3M™ F2000 compomer restorative, Dyract™, Compoglass™ and 3M Z100™ restorative was determined over about a ten minute interval by this method. The results are shown in Figure 32. F2000 compomer restorative, Dyract and Z100 restorative were found to shrink about the same amount, between 2.0 and 2.5 percent. Compoglass showed a slightly higher shrinkage.

Figure 32.
Volumetric Shrinkage



Post-gel shrinkage was also determined using strain gauge technology. The shrinkage of 3M™ F2000 compomer restorative and Z100™ restorative was determined over a 5.5 minute interval and results measured as microstrain of the material. Results are shown in Figure 33 where it can be seen that the microstrain of the F2000 compomer restorative was significantly lower than that of the Z100 restorative. The significance of lower post-gel shrinkage is that the bond between tooth structure and the compomer material is more reliable and the margins of the F2000 compomer restorative may be safer from minor fracture as there is less strain in the material.

Figure 33.
Post Gel Shrinkage



Water Sorption

As discussed previously, the F2000 compomer restorative includes a unique component that takes up water. While this component provides unique features to the compomer, the amount of water absorbed is of some interest. Will the uptake be too great? Will it cause the material to swell excessively? How does it compare with other materials used for similar clinical applications?

Water sorption was measured according to ISO specification 4049 for resin-based filling materials. For this measurement, a test sample was made, dried in a desiccator to a constant weight, weighed, then immersed in water at 37° C for one week, removed from the water, dried slightly and weighed again. Water sorption was calculated as the difference between the weight following water immersion and the conditioned dry weight divided by the volume of the sample. It is reported in micrograms per millimeter cubed.

The water sorption of F2000 compomer restorative, Dyract™ and Silux Plus™ restorative was determined. Results are presented in Table 4 where water sorption is given in the units indicated by the test specification. The water sorption value of the F2000 compomer restorative is similar to that of the microfill, Silux Plus restorative. The microfill restorative has been used by the dental profession for over a decade and has exhibited outstanding clinical performance especially in Class V restorations. Its water uptake is often credited for its excellent marginal seal.

Table 4.
Water Sorption

Material	Water sorption (ug/mm3)
F2000 compomer	39.3
Dyract	32.6
Silux Plus	43.4

Dimensional Change

To determine the dimensional change resulting from water sorption, test samples were formed as discs and light cured. Two cross-hatch scores were cut into each disc with a sharp blade and the distance between them was precisely measured. The samples were then placed in water at 37° C. The distance between the scores was measured again after three, seven and fourteen days, compared with the distance between the initial scores of the dry sample and the percent change calculated. The results are shown in Table 5. Again the 3M™ F2000 compomer restorative was similar in performance to that of Silux Plus™ restorative. Both demonstrated the same rate of change from three to seven days. There was no additional change in the F2000 compomer restorative from the seven to fourteen day measure and only a slight increase occurred with the Silux Plus restorative over this time interval. Both materials showed an overall small dimensional change. While the glass ionomer, Vitremer™ core buildup/restorative showed a greater dimensional change, its rate of change from the three day measure to the seven day measure was less than that of the other materials studied and was very minimal from seven to fourteen days.

Table 5. Dimensional Change Resulting from Water Sorption

Material	3 days	Percent change 7 days	14 day
F2000 compomer	0.24	0.38	0.37
Dyract	0.12	0.25	0.32
Silux Plus	0.26	0.41	0.46
Vitremer C/R	2.00	2.21	2.28

Coefficient of Thermal Expansion

The coefficient of thermal expansion of the major compomer products was also determined. Test samples were made as cylinders 4 mm in diameter and 2 mm in height. After light curing, they were immersed and aged in water for 7 days at 37° C. Using a thermo-mechanical analyzer, coefficient of thermal expansion was determined. Test results were calculated over the temperature range 10° C to 50° C and reported as parts per million (ppm) per degree C (°C). They are presented in Table 6. The thermal expansion coefficient of the F2000 compomer restorative is very similar to that of coronal tooth structure reported to be about 11 ppm/°C (Craig, Dental Materials). Given this close similarity, less stress and demand should occur to the bond between the F2000 compomer restorative and tooth structure during temperature cycles in the mouth. The values for the other compomer materials studied were found to be much higher than that of tooth structure.

Table 6. Coefficient of Thermal Expansion

Material	Coefficient of Thermal Expansion (ppm/°C)	Std. Dev.
F2000 compomer	12.6	4.9
Dyract	31.6	3.2
Compoglass	41.5	2.3

Microleakage

To assess microleakage, Class V cavities were prepared at the cementoenamel junction (CEJ) of extracted human third molars. The prepared cavities were circular and measured about 3 mm in diameter and 2 mm in depth. They were restored using 3M™ F2000 compomer restorative with 3M™ F2000 compomer primer/adhesive, F2000 compomer restorative with the 3M™ Single Bond adhesive system, Dyract™ with Prime & Bond™ 2.1 and Vitremer™ core buildup/restorative with Vitremer™ primer. After finishing the restorations, the teeth were stored in water at room temperature for 24 hours and then thermal cycled between 5° C and 55° C for about 650 cycles. They were then stained using silver nitrate and sectioned to expose the internal margins of the restorations. The enamel and dentin margins were scored for dye penetration using the arbitrary system shown schematically. Figure 34 shows the average scores for both the enamel and dentin margins of the materials investigated. Dyract was bonded using one coat of Prime & Bond 2.1 as is indicated in the United States and was not evaluated with a two coat technique. The F2000 compomer restorative with both adhesive systems showed minimal leakage similar to that of Vitremer core buildup/restorative. Dyract showed greater microleakage than the other materials evaluated.

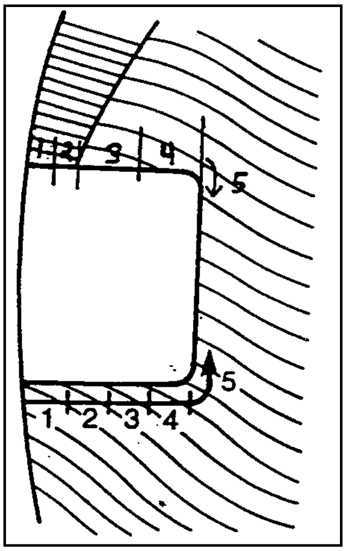
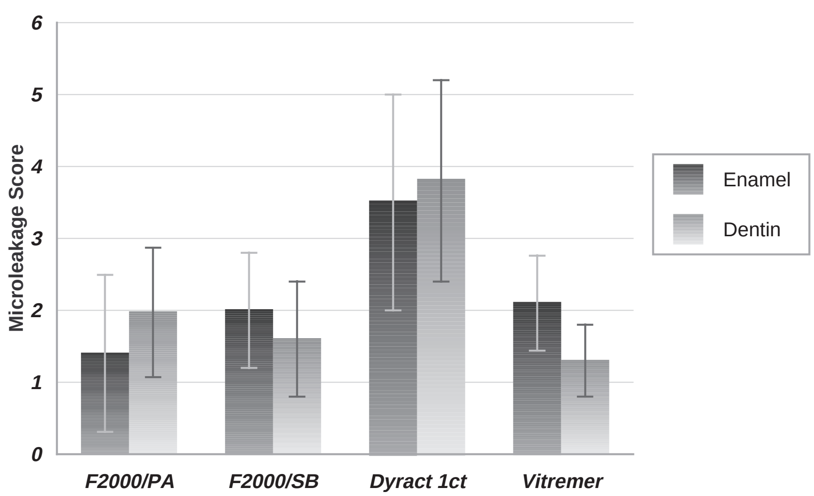


Figure 34.
Microleakage Scores



Radiopacity

Aluminum is used as the standard reference for radiopacity. According to ISO specification 4049 for Resin Based Filling Materials, a 2 mm thickness of material must have greater radiopacity than an equal thickness of aluminum. By this specification, F2000 compomer restorative is radiopaque.

Summary

The following is a summary of the features of the F2000 compomer restorative systems.

3M™ F2000 Compomer Restorative

- One part, light cure paste
- Available in both capsules and syringes
- Broad shade selection—13 shades available
- Multiple systems for bonding
  – Useable with 3M adhesive systems
  – Useable with F2000 compomer primer/adhesive
- Excellent handling characteristics
- Fluoride release
- High physical properties
- Radiopaque

3M™ F2000 Compomer Primer/Adhesive

- Hydrophilic water-based primer
- Contained in the unique 3M™ Clicker™ dispenser
- No separate etching needed for bonding F2000 compomer restorative
  – Saves steps, saves time
- Provides high bond strength to enamel and dentin without a separate etch
- Shows inhibition to in vitro artificial caries with F2000 compomer restorative

3M™ Clicker™ Dispenser

- Unique delivery device
- Provides simultaneous dispensing of two components
- Provides precise dosing
- Easy to use
- Clean/non-messy dispenser
- Allows for minimal skin contact with liquid contents
- Gauge shows number of applications remaining in dispenser

3M™ Single Bond Adhesive System

- One bottle adhesive
- Unique bottle
  – Orange color protects contents, allows visualization of remaining amount
  – Easy flip-top cap
- Excellent bond to enamel and dentin with etch technique
- Familiar bonding technique
- Useable with compomer and composite

Table 7.
Summary of Compomer Product Bonding Techniques Comparing the Steps and Approximate Times Required for the Bonding Procedures

	F2000 with F2000 P/A	**F2000 with Single Bond adhesive**	**Dyract with P&B 2.1-1 coat**	**Dyract with P&B 2.1-2 coats**	**Dyract AP with P&B 2.1**	**Compoglass with Compoglass SCA**	**Hytac Aplitip with Hytac OSB**
Apply etchant	—	5	—	—	—	—	—
Apply primer/adhesive	5	—	5	5	5	5	30
Wait	30	15	20	30	30	20	
Rinse	—	10	—	—	—	—	—
Dry	5-10	5	5	5	5	5	5
Light cure	10	—	10	10	10	20	10
Apply Single Bond adhesive-2 coats	—	15	—	—	—	—	—
Apply second coat of primer/adhesive	—	—	—	5	5	5	5
Dry	—	2-5	—	5	5	5	5
Light cure	—	10	—	10	10	20	10
Approximate time	50-55	62-65	40	70	70	80	65

Questions & Answers

Q. ***Will mixing parts A and B of the F2000 compomer primer/adhesive cause it to set?***

A. No, simply mixing the two parts does not initiate polymerization. F2000 compomer primer/adhesive will set only by light exposure. A 10 second exposure is recommended.

Q. ***How many applications of the F2000 compomer primer/adhesive are in the Clicker dispenser?***

A. When full, the Clicker dispenser has 80 applications. The gauge on the back of the dispenser plunger indicates the number of remaining applications.

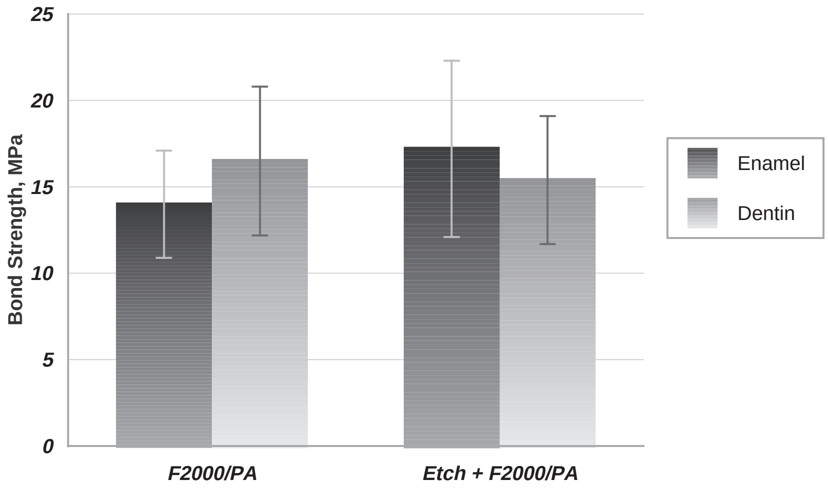
Q. ***What should be used to clean the cartridge tips of the Clicker dispenser?***

A. A 2×2 gauze dampened with alcohol is the best choice.

Q. ***What happens if enamel and dentin are etched with phosphoric acid before application of F2000 compomer primer/adhesive?***

A. There is little effect on the bond of the compomer restorative to dentin. The mean bond strength to enamel is somewhat higher with the additional etching but the values are not significantly different. Figure 35 shows the data graphically.

Figure 35.
Bond of F2000/PA.
Effect of Etching



Q. ***Is bond strength increased if two coats rather that a single coat of the F2000 compomer primer/adhesive are used?***

A. Considerable testing was done to determine if two or just one coat of the compomer primer/adhesive should be recommended. It was found that there was no significant difference in bond strength with one coat and with two coats. Since there is no real difference, having just one application and one light curing step is a faster, easier and more economical technique for the dental team.

Q. ***Can the F2000 compomer primer/adhesive be used to bond composite to enamel and dentin?***

A. No, the F2000 compomer primer/adhesive was designed to bond the F2000 compomer restorative. When tested for bonding composite, bond strengths were significantly lower and unacceptable.

Q. ***Can the Single Bond adhesive and Scotchbond™ multi-purpose adhesive systems be used without etching?***

A. No, eliminating the etching procedure with these adhesive systems negatively affects the bond to both enamel and dentin lowering them significantly. Etching with both adhesive systems is essential to obtain an adequate bond to tooth structure whether bonding the F2000 compomer restorative or a composite.

Q. ***Will fluoride release cause weakening of the F2000 compomer restorative?***

A. No. If the F2000 compomer restorative were weakened by the release of fluoride it would be evident by a decline in physical properties. The diametral tensile strength of F2000 compomer restorative measured over an eleven week period showed no significant change. Samples were stored in water at 37° C over the test period which allowed fluoride to be released and yet there was no significant decline in the measured physical property.

Q. ***Since water absorption is needed for fluoride release and since fluoride release is sustained over time, will the F2000 compomer restorative continue to take up fluid and expand?***

A. No. Testing indicates that dimensional change in the F2000 compomer restorative resulting from water uptake stabilizes between three and seven days. There is only about a 0.4% dimensional change from its initial dry state to seven days in water and no change from seven to fourteen days.

Q. ***Will its fluid uptake and resulting expansion negatively impact the use of the F2000 compomer restorative as a core buildup material?***

A. It is not believed so. The water sorption of F2000 compomer restorative and dimensional change resulting from it are considerably less than that of Vitremer™ core buildup/restorative. Vitremer core buildup/restorative has been clinically successful as indicated for core buildup since its introduction in 1992.

Q. ***Since the F2000 compomer primer/adhesive is acidic and is not rinsed off the tooth in clinical use, what will be the long term effect on the tooth?***

A. No negative effect is expected. Many investigators have studied the effect of placing acids on dentin. It has been found that dentin has a great buffering capacity which protects pulpal tissue from the effects of acids.

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