Comparative Clinical Evaluation of Different Treatment Approaches Using a Microfilled Resin Composite and a Compomer in Class III Cavities: Two-year Results

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Clinical Relevance
For two years, the three restoration/adhesive combinations used in this study (Dyract AP/Prime & Bond NT with NRC pretreatment, Dyract AP/Prime & Bond NT with phosphoric acid pretreatment and Filtek A110/Single Bond) exhibited very good clinical performance in Class III cavities. Clinically simplified systems and handling characteristics of materials may effect their clinical performance.

SUMMARY
This study evaluated the 24-month clinical performance of a microfilled composite using a one-bottle bonding system and a compomer that uses one-bottle bonding systems, which include a non-rinse conditioner or 36% phosphoric acid gel in Class III cavities.

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DOI: 10.2341/07-34
brated examiners using the modified Ryge criteria.

After two years, one restoration from each group had a rating of Charlie (C) for both color match and marginal discoloration and needed to be replaced. Therefore, the failure rate was 3.6% (success rate: 96.4%) for each group at the end of two years. Statistical analysis showed no significant differences among the three groups in color match, marginal discoloration, wear or loss of anatomical form, marginal adaptation and surface texture after two years. Also, no statistically significant differences were determined for each group with respect to color match, marginal discoloration, wear or loss of anatomical form, marginal adaptation and surface texture at the end of two years.

INTRODUCTION

The basic mechanism of bonding to enamel and dentin is essentially an exchange process involving the replacement of minerals removed from the hard dental tissue with resin monomers that become micro-mechanically interlocked in the created porosites. In addition to the number of application steps, adhesives can be classified based on the underlying adhesion strategy as “etch & rinse,” “self-etch” and “resin-modified glass-ionomer adhesives.”

Following an “etch-and-rinse” approach, the tooth is first etched (mostly 30%-40% phosphoric acid) and rinsed off. This conditioning step is followed by a priming step and application of the adhesive resin, resulting in a conventional three-step application procedure. This etch-and-rinse technique is the most effective approach to achieving efficient and stable bonding to enamel. For dentin, the primary bonding mechanism of etch-and-rinse adhesives is primarily diffusion-based and depends upon hybridization or micro-mechanical interlocking of resin within the exposed collagen fibril scaffold. Simplified two-step etch-and-rinse adhesives combine the primer and adhesive into one application (often referred to as “one-bottle” adhesives).

Recently, the one-bottle bonding system referred to as Single Bond in the USA (3M ESPE, St Paul, MN, USA) and Scotchbond 1 in Europe was introduced. This bonding system creates a mechanical interlocking to conditioned dentin with resin tags, adhesive lateral branches and the formation of a hybrid layer, showing high bond strength values both to the conditioned dentin and etched enamel. In combination with restorative materials, Scotchbond 1 is clinically indicated for all classes of cavities and can also be used to desensitize exposed root surfaces.

The small size of the filler particles of colloidal silica enables microfilled composites to be polished to a very smooth surface finish. The large surface area of the microparticles means that it is impossible to have high filler loading. Increased content of unfilled resin reduces mechanical properties. According to the manufacturer, Filtek A110 Anterior Restorative (3M ESPE) is an esthetic, light cured, microfill restorative specifically designed for use in anterior direct or indirect restorations. The filler is silica, with an average particle size of 0.04 microns (particle size distribution of 0.01-0.09 microns). The inorganic (silica) filler loading is 56% by weight or 40% by volume and is not radiopaque. Bonding to the tooth structure is accomplished by using a dental adhesive system, such as Single Bond Dental Adhesive or Scotchbond.

Most recently, adhesive systems with stress-absorbing potential through the incorporation of fillers have been introduced. Most filled adhesives still require a two-step application. A primer is first applied on a previously conditioned tooth surface, followed by the filled bonding agent. A new dental adhesive, Prime and Bond NT (Dentsply-DeTrey, Konstanz, Germany), simplifies these procedures by incorporating the fillers into the combined primer-adhesive solution, thereby reducing the application steps. The manufacturer suggests that this adhesive may be used in conjunction with Dyract AP (Dentsply-DeTrey) with conditioning protocols that are usually recommended: (i) non-rinse conditioner (NRC, Dentsply-DeTrey), a self-priming conditioning liquid with organic acidic components that copolymerize with the subsequently applied adhesive and (ii) 36% phosphoric acid gel, which requires rinsing prior to application of the dentin adhesive.

Compomers are light-curing, fluoride-releasing, one-component materials that are very similar to composites. They contain acid-decomposable glass and acidic polymerizable monomers with acidic carboxylate groups and polymerizable methacrylate groups, which enable free radical polymerization by light curing and an acid-base reaction in the presence of water. Compomers are easy to handle, and their esthetic properties resemble composites, while some compomers' wear characteristics also resemble composites. Dyract was the first compomer introduced. Dyract AP, a second-generation compomer with a smaller filler particle size, higher fluoride release and easier polishing, was introduced to the market in 1998. This compomer was recommended for unrestricted use in all cavity classes, including stress-bearing occlusal surfaces, in both primary and permanent teeth.

This study evaluated the 24-month clinical performance of a microfilled composite using a one-bottle bonding system and a compomer using one-bottle bonding systems: a non-rinse conditioner or 36% phosphoric acid gel in Class III cavities.
METHODS AND MATERIALS

This clinical study was performed at the Department of Conservative Dentistry, Istanbul University. Thirty-two patients participated in the study: 12 male and 20 female, ranging in age from 14 to 53 years (mean age: 25.8), with good oral hygiene and sound periodontal conditions. When the study began, the Ethics Committee of Istanbul University Faculty of Dentistry had not been established. However, informed consent was obtained from each patient prior to treatment. Three types of restoration/adhesive combinations were used: a microfilled resin composite (Filtek A110) with a one-bottle bonding system (Single Bond), a polyacid-modified resin composite (compomer) (Dyract AP) with a filled one-bottle bonding system (Prime & Bond NT) using a 36% phosphoric acid pretreatment and Dyract AP with a filled one-bottle bonding system (Prime & Bond NT) using a non-rinse conditioner (NRC) and a self-priming pretreatment. Each patient received three restorations due to primary caries of the anterior or teeth, resulting in 96 total restorations. Eighty-eight lesions were chosen for treatment in the maxillary anterior (53 in central, 29 in lateral, 6 in canine) and 8 in the mandibular anterior (4 in central, 2 in lateral, 2 in canine).

All cavities were prepared and the restorations placed by the same operator. Cavity preparation was limited to the removal of caries. The incisal margins of the cavities were cervical to the incisal edge of the teeth, and the cervical margins were at/or incisal to the cemento-enamel junction. For the Filtek A110/Single Bond restoration combination, all enamel margins were beveled 0.5-1.0 mm at approximately a 45° angle to the external cavosurface using a high-speed, water-cooled rotary handpiece with a medium-grit diamond bur. After the cavities were prepared, the manufacturer’s instructions were closely adhered to regarding cavity treatment and placement of the restorative material. Isolation was achieved with cotton rolls and saliva ejectors in all cases.

With each patient, the following three restoration/adhesive combinations were performed:

1-Dyract AP/Prime & Bond NT with NRC pretreatment (Group I): One coat of NRC was applied for 20 seconds and not rinsed. Excess NRC was removed by gentle blowing with a dental air syringe. Then, one coat of Prime & Bond NT was applied. The cavity surface was saturated with the adhesive and left undisturbed for 20 seconds. The excess solvent was removed with a gentle blow of air. The operator checked the surfaces to confirm that they were uniformly glossy before light curing for 10 seconds. Dyract AP was placed and light-cured for 40 seconds. Following removal of the excess material with fine diamond burs and strips, the restorations were finished and polished with Sof-Lex abrasive disks (3M ESPE).

2-Dyract AP/Prime & Bond NT with phosphoric acid pretreatment (Group II): Enamel and dentin surfaces were etched with 36% phosphoric acid gel for 20 seconds. After application of the conditioning gel, the cavity was rinsed for 15 seconds, then gently air-dried for 1-2 seconds, leaving the surfaces wet. Next, one coat of Prime & Bond NT was applied. The cavity surface was saturated with the adhesive and left undisturbed for 20 seconds. The excess solvent was removed with a gentle blow of air. The operator checked the surfaces to confirm that they were uniformly glossy before light-curing for 10 seconds. Dyract AP was placed and light-cured for 40 seconds. Following removal of the excess material with fine diamond burs and strips, the restorations were finished and polished with Sof-Lex abrasive disks (3M ESPE).

3-Filtek A110/Single Bond (Group III): Enamel and dentin surfaces were etched with 36% phosphoric acid gel for 15 seconds. The surfaces were rinsed with water for 15 seconds, then lightly blot-dried with a cotton roll, with the surfaces remaining moist. Two consecutive coats of adhesive were applied and gently air-dried for five seconds. The adhesive was then light-cured for 10 seconds. Filtek A110 was placed and light-cured for 40 seconds. Following removal of the excess material with fine diamond burs and strips, the restorations were finished and polished with Sof-Lex abrasive disks (3M ESPE).

The color matching of the restorations was achieved with a Vita shade guide (Vita Zahnfabrik, Bad Sackingen, Germany). With restorations having depths of more than 2 mm, the material was applied using the incremental technique. The first material layer was applied on the pulpal walls and light cured for 40 seconds. Then, a second layer was applied and light cured for an additional 40 seconds. In shallow cavities, the material was placed in a single increment and light cured for 40 seconds from both the buccal and palatal sides. The intensity of the curing light (XL3000, 3M ESPE) was measured before and after application and the light output was never below 450 Mw/cm².

The restorations were evaluated by two experienced calibrated examiners using the modified Ryge criteria (Table 1).² At baseline, one- and two-year recalls, color match, marginal discoloration, wear or loss of anatomical form, caries, marginal adaptation and surface texture were evaluated.

According to the modified Ryge criteria, Alpha (A) indicates a clinically ideal situation, Bravo (B) indicates a clinically acceptable situation, except for caries, which requires replacement of the restoration; Charlie (C) is a clinically unacceptable situation, where
replacement of the restoration is required and Delta (D) indicates a situation where the restoration is unacceptable due to fracture, mobility or loss and needs to be replaced.

The data were subjected to a Kruskal-Wallis test to determine differences for each treatment between recalls and Friedman's two-way ANOVA test to detect differences among the treatments for each criterion at the end of the 24 months. The level of significance was set at \( p \leq 0.05 \).

### RESULTS

After one year, all patients participated in their recall visits. At the two-year recall, three patients (nine restorations) dropped out. Recall rates for patients at years one and two were 100% and 90.6%, respectively.

<table>
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<tr>
<th>Table 1: Direct Clinical Evaluation Criteria (Modified Ryge Criteria)</th>
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<tr>
<td><strong>Rating</strong></td>
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<td>Alpha (A)</td>
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<td>Bravo (B)</td>
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<td>Charlie (C)</td>
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**Color Match**

**Cavosurface Marginal Discoloration**

**Wear/Anatomic Form**

**Caries**

**Marginal Adaptation**

**Surface Texture**
The reason for dropping out was that some patients did not return for their examinations.

A 100% retention rate for the remaining restorations was recorded at the end of one and two years for each group. After two years, one restoration from each group had a score of Charlie (C) for color match and marginal discoloration and required replacement. Therefore, the failure rate was 3.6% (success rate: 96.4%) for each group at the end of two years.

Statistical analysis showed no significant differences between each group in color match, marginal discoloration, wear or loss of anatomical form, marginal adaptation and surface texture between baseline and two-year results. Also, no statistically significant differences were determined within each group with respect to each evaluation criteria after two years. No secondary caries was detected during the two-year period for each group. Also, at baseline, one- and two-year recalls, none of the patients reported sensitivity.

At baseline, the color match for Groups I, II and III were rated Bravo in 3.1, 6.3 and 21.9% (1, 2 and 7 out of 32) of the restorations, respectively. Also, with regard to wear/anatomic form, Groups I and III had a score of Bravo in 3.1% (1 out of 32) of the restorations.

After one year, there were no color and anatomic form/wear changes with the same Bravo ratings as baseline for each group. With respect to marginal discoloration, Groups II and III had Bravo ratings of 6.3% and 9.4% (2 and 3 out of 32) restorations, respectively.

At the end of two years, 31% of the Group III restorations were rated Bravo with respect to color match. This indicated an increase of 8.1% when compared to the one-year recall. Also, Groups I and III were rated Bravo in 17.2% (5 out of 28) of the restorations with respect to marginal discoloration after two years; whereas 10.3% (3 out of 28) of Group II restorations had marginal discoloration (Bravo rated). Only at the end of the second year did Group III have a rating of Bravo in 3.6% (1 out of 28) of the restorations with respect to anatomic form/wear. After two years, with respect to marginal adaptation, Groups I and III were rated Bravo in 7.1 and 10.8% (2 and 3 out of 28) of restorations, respectively.

**DISCUSSION**

This study examined the clinical effectiveness of three restoration/adhesive combinations (Dy racket AP/Prime & Bond NT with NRC pretreatment, Dy racket AP/Prime & Bond NT with phosphoric acid pretreatment and Filtek A110/Single Bond) in Class III cavities. After two years, each restoration type performed with a high clinical success rate (96.4%). In a recent clinical study in which the clinical performance of Filtek A110/Single Bond restorations was examined, Perdigão, Carmo and Geraldeli reported 100% to 89% success rates on dry and moist dentin for non-carious cervical lesions after two years, respectively. Other authors investigating Single Bond with other resin composites placed in Class I and V cavities found 100% to 93.6% success rates after two years, respectively. Also, other clinical studies reported 95.6% to 90% success rates of Dyract AP/Prime & Bond NT with NRC pretreatment in Class V carious and abrasion/erosion lesions and in permanent posterior teeth after two years.

The handling characteristics of materials are very important in reducing the chances of early failure. The great acceptance of compomers is primarily due to their easy handling, particularly in dentistry for children. In fact, the clinical procedures for applying these materials in cavities are easy and free of the conventional problems related to the use of hybrid resin composites, such as stickiness, fluidity, strict isolation and multi-step application. Bonding procedures to tooth structures generally require multiple-step clinical applications. Therefore, the clinical success of these adhesive systems depends on technique-sensitive and material-related factors.

The last decade has seen the introduction of clinically simplified systems (often called “one-bottle systems”) for the bonding of resin composite materials to dentin, with two approaches being used. First, the etch and primer have been combined to form a self-etching primer, followed by application of the adhesive and resin-based composite. The second, and more common approach, has been to use a conventional (phosphoric acid) etch, followed by a combined primer/adhesive, then application of the resin composite. An example of this latter approach is Single Bond.

At baseline, Group III restorations demonstrated a high percent of color mismatch (21.9% Bravo rating) when compared to Group I or II restorations. One possible reason for the high percentage of color mismatch may be a change in color during light curing. It has been reported that changes in color during light curing may be within the range of an unacceptable color change. Johnston and Reisbick insist that the color and translucency of esthetic restorative materials is determined not only by more macroscopic phenomena, such as matrix, filler composition and filler content, but also by relatively minor pigment additions and potentially by all other chemical components of these materials. Moreover, Inokoshi and others stated that the higher the refractive index difference between inorganic particles and the matrix phase of resin composites, the greater the opacity of the materials, due to multiple reflections and refractions at the matrix particle interfaces. On the other hand, none of the restorations in each group showed color change after one year. However, the clinically acceptable color match rate (Bravo rating) declined 9.1% with respect to baseline.
and was 31% in Group III restorations. Only one restoration in each group (3.6%) had an unacceptable color match (Charlie) and had to be replaced. Other authors who investigated Filtek A110 restorations by placing non-carious cervical lesions found that, after 18 months, 100% to 84% of restorations revealed Alpha ratings for color match.\textsuperscript{17,20} Compared to those results, a lower ideal color match rate (Alpha) was observed in the current study after two years. This difference might be due to the different cavity types selected in the two studies. Additionally, three main reasons can be responsible for postoperative alterations in the shade match of a filling: (1) the deposition of exogenous, colored pigments on the surface, (2) alteration of the interface between the organic matrix and the filler particles and finally (3) chemical reactions of the resin matrix itself.\textsuperscript{20}

Alternatively, in a recent study in which in vivo comparisons of a microfilled and hybrid minifilled resin composite in Class III restorations were made, Reusens, D’hoore and Vreven\textsuperscript{1} reported that the microfilled composite (Silux Plus) showed a greater degradation in color match during the first week. Also, this microfilled resin composite seemed to become lighter and more opaque than the hybrid resin composite. This change was attributed to the fact that the main differences between the two resin composite materials was the significantly higher organic matrix and the smaller filler particles in the microfilled resin composite.\textsuperscript{6} Although there were differences between the current and previous studies in regard to cavity type, other authors investigating Dyract AP/Prime & Bond NT with NRC pretreatment placed in Class I and V cavities found that 96.1% to 88.9% of the restorations exhibited an ideal (Alpha) color match after two years.\textsuperscript{15,20}

Statistical analysis did not reveal significant differences for the two-year observations among the three restoration groups with regard to marginal discoloration and marginal adaptation. Group I and Group III restorations showed the same rate (17.2%) of marginal discoloration. Group II restorations had the least marginal discoloration (10.3%) after two years. This discoloration was only located on an unspecific point on the enamel surrounding the restoration and could be polished away, indicating that it did not progress towards the pulp, making it a clinically acceptable situation. Only one restoration from each group had deep discoloration (Charlie) and required replacing.

Regarding marginal adaptation, Group II restorations had no crevice; whereas, Group III restorations had a crevice (Bravo) in three restorations (10.7%), while Group I had a crevice in two restorations. However, in the restorations with a crevice, dentin was not exposed, which was clinically acceptable. The higher number of Group III restorations with a crevice (Bravo) is likely due to increased resin content. Poor marginal adaptation is associated with shrinkage that occurs during polymerization of the resin-based composite or improper application of the bonding agent.\textsuperscript{41}

Polymerization shrinkage of resin-based composite ranges between 2% and 4% and produces stress and marginal openings at the resin-based composite-to-tooth interface.\textsuperscript{31} Marginal openings allow leakage and staining and can ultimately lead to caries.\textsuperscript{14} Supporting the current findings, van Dijken and Horstedt\textsuperscript{34} reported more and severe marginal defects with microfilled composite fillings than with hybrid composite fillings in a Class III study. Thus, they suggested that greater polymerization shrinkage of microfilled composites in combination with a higher coefficient of thermal expansion might have resulted in more defects.

Perdigão, Carmo and Geraldeli\textsuperscript{17} investigated the clinical performance of Single Bond with Filtek A110 on dry vs moist dentin in non-caries cervical lesions for 18 months. Respectively, 97% and 88% of the restorations had no marginal discoloration on moist and dry dentin. Additionally, 76% and 84% of the restorations rated Alpha for marginal adaptation on moist and dry dentin, respectively. The difference between these results and that of the current research might be due to the application technique and different cavity types selected in the two studies.

Regarding marginal discoloration and marginal adaptation, Group II presented the best clinical performance. Other authors investigating Dyract AP/Prime & Bond NT with NRC pretreatment placed in Class I and V cavities found that 100% to 50% of the restorations were rated Alpha for marginal discoloration and 93.3% to 26.3% of restorations were rated Alpha for marginal adaptation after two years.\textsuperscript{15,20} Perdigão\textsuperscript{31} stated that, although Dyract has now been superseded by Dyract AP with a finer filler particle, a cross-linking resin and optimized initiator system, the manufacturers should still consider specifying mandatory enamel etching. Following acid etching, Prati and others\textsuperscript{41} found that Dyract exhibited, although not statistically significant, less marginal discoloration than a resin composite. Supporting those findings, Folwaczny and others\textsuperscript{35} showed that, without acid etching, Dyract demonstrated more marginal discoloration than another resin composite. Moreover, Di Lenarda, Caderano and De Stefano Dorigo\textsuperscript{36} reported marginal discoloration as high in the non-etched group (40%), with a statistically significant difference if compared to the etched group (16.7%) in cervical compomer restorations after 48 months. It may be thought that acid etching reduced marginal discoloration and improved marginal adaptation in the current study. The adhesion of Dyract AP to the tooth is also thought to be obtained through ionic bonds between the hydrophilic phosphate group of the constituent dipentaerythritol pentacrylate monophosphate (PENTA) and calcium of the hydroxyapatite.\textsuperscript{36} Further adhesion is thought to be achieved through the
hydrophilic reaction product between the butane tetracarboxylic acid and hydroxyethyl methacrylate (TCB) monomers present in the restorative.³⁷

At the one-year recall, no changes in wear or anatomical form were observed in the Group II restorations; whereas 96.9% of the restorations in Groups I and III were ideal (Alpha) for wear and anatomical form. After two years, only 3.6% of the restorations in Group III were at clinically acceptable (Bravo) levels of wear and anatomical form. On the other hand, all of the restoration surface textures were rated Alpha at the end of two years. Also, secondary caries was not detected in any restoration group.

CONCLUSIONS

After two years, only one restoration from each group had to be replaced due to non-acceptable (Charlie) color match and marginal discoloration scores. Therefore, the failure rate at the end of two years was 3.6% (success rate: 96.4%) for each group. However, there was no statistically significant difference within each group in color match, marginal discoloration, wear or loss of anatomical form, marginal adaptation and surface texture between the baseline and two-year results. Also, statistical analysis revealed no significant differences between groups with respect to color match, marginal discoloration, wear or loss of anatomical form, marginal adaptation and surface texture at the end of two years. However, some trends, although not statistically significant, were noted. Group III restorations demonstrated a higher percent of color mismatch (Bravo). Group II presented the best clinical performance with regard to less marginal discoloration and better marginal adaptation.

(Received 21 February 2007)

References


