Clinical evaluation of polyacid-modified resin composite posterior restorations: One-year results

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Objective: The aim of this investigation was to evaluate the clinical performance of a new compomer restorative system, Dyract AP, placed in combination with Non-Rinse Conditioner and Prime & Bond NT in permanent posterior teeth. Method and materials: Fifty Class II and 41 Class I restorations were placed in 39 patients by 1 dentist. The restorations were evaluated directly, with modified US Public Health Service criteria, and indirectly, with color slides and polyvinyl siloxane impressions, at baseline and 6 months and 1 year after placement. Preoperative and 1-year postoperative bitewing radiographs were also taken. Results: All 82 restorations available for 1-year evaluation were in situ. No postoperative sensitivity or pulpal problems were reported. Four Class II restorations (4.9%) failed because of partial fracture or recurrent caries. The percentages of Alpha score for each criterion were color match, 95.1%; marginal discoloration, 57.3%; marginal integrity, 35.4%; anatomic form, 98.8%; and surface texture, 91.5%. The average wear rate of Dyract AP was low (18.5 ± 11.7 μm at 6 months and 35.7 ± 13.6 μm at 12 months).

Conclusion: The excellent handling characteristics, the good clinical performance, and the improved wear resistance suggest that this compomer will provide reliable direct tooth-colored restorations in stress-bearing areas. (Quintessence Int 2000;31:630–636)

Key words: clinical evaluation, compomer, polyacid-modified resin composite, wear

Polyacid-modified resin composite (PMRC) was introduced in the early 1990s. It was developed as a direct esthetic restorative material that combined the desirable properties of light-curing composites with those of fluoride-releasing glass-ionomer cements (GICs). Unlike resin-modified glass-ionomer cement (RMGIC), PMRC is a single, hydrophobic resin, filled with the acid-leachable glass particles of a glass-ionomer cement, which makes it closer to resin composite than to GIC from a chemical point of view. Commercially, the term compomer (composite-ionomer) is used to reflect its resin composite and glass-ionomer derivation. The excellent physical characteristics of this new category of restorative materials (esthetic, easy handling, adhesion to tooth structure, fluoride release, improved physical and mechanical properties, biocompatibility, radiopacity, ease of finishing, etc) have been described by their manufacturers. Nevertheless, their substantial wear and poor abrasion resistance, reported in clinical studies, remain potential weaknesses.

Peters et al reported that the wear of Dyract (Dentsply DeTrey) compomer restorations in primary molars is considerable, 100 μm at 6 months and 190 μm (range 100 to 500 μm) at 1 year, measured with the Moffa-Lugassy scale. Hse and Wei measured the wear value of Dyract restorations in primary dentition with the Rheinberger scale and found that the compomer exhibits a wear rate about 3 times that of a hybrid resin composite. Many independent laboratory studies have been carried out to compare the physical and mechanical properties of PMRCs with those of other dental restorative materials, such as RMGICs, conventional GIC, and hybrid resin composite. Although different values were obtained with different test methods, the physical properties of PMRCs were...
found to be inferior to those of hybrid resin composites. Low resistance to wear was also noted, and, thus, PMRC was not recommended for use in occlusal stress-bearing areas in permanent restorations. Recently, a new light-cured, single-component PMRC, Dyract AP (Dentsply DeTrey), was introduced. Compared with its earlier version (Dyract), Dyract AP has higher compressive and flexure strengths, and its wear resistance is similar to that of resin composites. Therefore, Dyract AP is recommended by the manufacturer for use in all cavity types in anterior and posterior teeth, including the occlusal stress-bearing surfaces of permanent teeth. However, these ideal physical properties and the wear performance should be confirmed by long-term clinical studies.

Non-Rinse Conditioner (NRC) is a self-etching primer (Dentsply DeTrey) that needs no rinsing after 1-coat application. The manufacturer recommends NRC for conditioning both enamel and dentin and for use in combination with Prime & Bond NT (Dentsply DeTrey) and Dyract AP compomer in stress-bearing Class I and Class II permanent restorations. Prime & Bond NT is a self-priming dental adhesive that combines primer and adhesive in a single bottle. It is designed to bond Dyract AP compomer or resin composite materials to enamel and dentin.

The objective of this study was to describe the clinical performance of Dyract AP, used in combination with NRC and Prime & Bond NT, for occlusal stress-bearing Class I and Class II restorations in permanent teeth.

METHOD AND MATERIALS

Operative procedures

A total of 39 subjects, 15 male and 24 female, with a mean age of 29 years (aged 13 to 54 years), were chosen from patients attending the Prince Philip Dental Hospital in Hong Kong. Ethics Committee approval was obtained for this clinical trial. All patients were requested to sign an informed consent form to participate in the study.

Each subject had 1 to 4 permanent molars or premolars with clinically and radiographically detected cavities that required restoration. The study sample included 41 Class I and 50 Class II restorations at baseline. The maxillary teeth involved were 9 first premolars, 24 second premolars, 16 first molars, and 4 second molars. The mandibular teeth were 6 second premolars, 10 first molars, 20 second molars, and 2 third molars. All of the restorations had opposing occlusion at the time of placement.

All study subjects were referred to dental hygienists for scaling and instructions in plaque control before treatment. Shade selection was made prior to the restorative procedure while the teeth were moist. All teeth were treated after administration of a local anesthetic and under rubber dam isolation by 1 operator. For deep cavities, a light-cured glass-ionomer liner (Fuji Lining LC, GC) and/or a calcium hydroxide base (Dycal, Dentsply Caulk) was placed under the restoration to protect the pulp. For Class II restorations, a Tofflemire metal matrix (Buffalo Dental) and wooden wedges were used.

The Dyract AP restorative system was used according to the manufacturer's instructions. One layer of NRC was applied with an applicator tip for 20 seconds and not rinsed. Excess solvent was removed by gentle blowing with a dental air syringe. This was followed by the application of 1 coat of Prime & Bond NT. The cavity surface was saturated with the adhesive and left undisturbed for 30 seconds. The excess solvent was removed with a gentle stream of air and light-cured for 20 seconds. The Dyract AP restorative material was placed incrementally (no more than 3 mm), and each increment was light cured separately for 40 seconds. Class II restorations were cured for an additional 40 seconds through the buccal and lingual walls after removal of the matrix and wedges.

Gross excess of the restorative material was removed with polishing diamond points and multifluted tungsten carbide burs. The proximal surfaces were smoothed with graded Sof-Lex strips (3M Dental). Additional finishing and polishing were obtained with Enhance Finishing and Polishing Discs and Prisma Gloss (Dentsply DeTrey).

Direct evaluations

Two trained assessors evaluated the restorations at baseline, and 1 of them assessed all restorations at subsequent reviews at 6 and 12 months after placement. Agreements on the use of the evaluation criteria were obtained before the baseline evaluation. All evaluations were carried out under normal clinical conditions with a dental operating light, a front-surface mouth mirror, a dental explorer, and an indexed periodontal probe. The assessors directly evaluated the color match, marginal discoloration, marginal integrity, anatomic form, recurrent caries, and surface texture according to the modified United States Public Health Service (USPHS) scoring system. The status of the gingiva adjacent to Class II restorations was recorded with the sulcular bleeding index. Postoperative sensitivity was determined by interviewing the patients and by clinical examination of the treated teeth.
**Indirect evaluations**

Clinical color slides (ISO 100, Eastman Kodak) of each involved tooth were taken at ×1.5 magnification before treatment, after cavity preparation, and immediately after restoration placement. Slides were also taken at the 6-month and 12-month recalls. Indirect evaluations were made from the slides for color match, marginal staining, and surface porosity. The maximum width of the occlusal cavity opening was also measured.

An impression of each restoration was made with a polyvinyl siloxane impression material (Imprint, 3M Dental) at baseline and subsequent recall times. The impressions were poured in die stone, and the replicas were evaluated against a standard Rheinberger scale model (Vivadent) to estimate the amount of occlusal wear. Evaluations of interproximal contour and contact, marginal integrity, and bulk fracture of restorations were also made from the die stone replicas. All indirect assessments were repeated for 30 randomly selected restorations to assess intraexaminer reproducibility. The Kappa statistics score for each criterion ranged from 0.6 to 1.0.

**Statistical analyses**

All data were entered into an Excel 7.0 (Microsoft) spreadsheet and analyzed with SAS software. Fisher's exact test and a chi-square test were used to compare the distribution of assessment scores between the evaluation times. In the comparison of wear values obtained at different recalls, a paired t test was used. A difference was statistically significant when \( P \leq 0.05 \).

**RESULTS**

The number of restorations available for evaluation is shown in Table 1. The mean cavity width was 4.1 mm (SD = 1.1 mm). One 3-surface (mesio-occlusodistal) Class II restoration failed because of fracture on the distal proximal box. Another 3 restorations showed early signs of recurrent caries, resulting in a failure rate of 4.9% after 1 year. All failed restorations were Class II. No postoperative sensitivity or pulpal problems related to the restorative material were observed at the 1-year follow-up.

Because no statistically significant difference was found between the Class I and Class II restorations for each criterion \( (P > 0.05) \), they were pooled in this report. Table 2 shows the results for the restorations evaluated directly and indirectly at each recall time.

**Color match**

During the first year, the study restorations demonstrated good color stability. Initially, 2 restorations received a Bravo rating for mismatching the color of the adjacent tooth structure, which was probably a result of incorrect shade selection prior to placement. At the 12-month evaluation, the ratings of 2 restorations changed from Alfa to Bravo, because the restorations appeared a little darker than the adjacent tooth tissue. Despite these, color match remained acceptable in all restorations, and 95.1% of the restorations showed excellent color-matching ability (Alfa) over the 12-month period.

**Marginal discoloration**

Minor marginal staining was detected more easily from color transparencies than from chairside examination. The proportions of restorations with slight marginal discoloration (Bravo) were 5.5% at baseline, 21.4% at 6 months, and 42.7% at 12 months, and the differences between each recall time were statistically significant \( (P < 0.01) \). However, this rating was clinically acceptable, and replacement of the restorations was not indicated.

**Marginal integrity**

From the indirect evaluation of die replicas and color slides under magnification, many restorations were found to have minor marginal defects at the 12-month recall. Some of the defects were related to fracture of excess material, which may be attributed to the finishing technique of the operator. Only 35.4% of the restorations were rated Alfa after 1 year, and the differences...
TABLE 2 Results of direct and indirect evaluations of Dyract AP restorations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>6 mo</th>
<th>12 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rating</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Color match*</td>
<td>A</td>
<td>89</td>
<td>97.8</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>Marginal discoloration</td>
<td>A</td>
<td>86</td>
<td>94.5</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>Marginal integrity†</td>
<td>A</td>
<td>89</td>
<td>97.8</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Anatomic form*</td>
<td>A</td>
<td>91</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Recurrent caries‡</td>
<td>A</td>
<td>91</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Surface texture*</td>
<td>A</td>
<td>86</td>
<td>94.5</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>Gingival status†</td>
<td>SBI = 0</td>
<td>37</td>
<td>74.0</td>
</tr>
<tr>
<td>(Class II only)</td>
<td>SBI = 1</td>
<td>13</td>
<td>26.0</td>
</tr>
</tbody>
</table>

*Evaluation of color slide.
†Evaluation of diestone replica.
‡Direct clinical evaluation.
§Radiographic and clinical evaluations.
·Statistically significant difference (P < 0.01) between each recall time.
*Statistically significant difference (P < 0.01) between baseline and 6 months or 12 months.
A = Alpha; B = Bravo; C = Charlie.
SBI = Sulcular Bleeding Index.

Among the baseline evaluation (97.8%), the 6-month evaluation (59.5%), and the 12-month evaluation were statistically significant (P < 0.01).

One Class II (mesio-occlusodistal) restoration received a Charlie rating for marginal integrity as well as anatomic form. Some restorative material had been lost from the distal proximal box, but a smooth edge was left, suggesting that the top increment of Dyract AP might have been dislodged from the layer below. Replacement of the restoration was not indicated, because the major part of the restoration was still functioning and the patient had no complaint.

**Recurrent caries**

Brown discoloration was observed clinically at the gingival line angle of the proximal box in 2 Class II restorations at the 12-month recall. The signs of potential recurrent caries were confirmed by indirect evaluation from radiographs. Secondary caries was also detected with a bitewing radiograph in another restoration. These 3 restorations (5.7% of the restorations) contributed to the failure rate. No treatment was indicated at this stage, because there was no loss of tooth structure, the discoloration was superficial, and the lesions were restricted to enamel.

**Surface texture**

Most of the restorations showed a smooth surface comparable to the adjacent enamel. Based on detailed indirect observations from color slides and die replicas, 2 restorations were found to have improved in surface roughness, from a Bravo to an Alfa rating, after 1 year; this change may have resulted from the wear on the occlusal surfaces. Three more restorations showed a slightly porous surface and were rated Bravo at the 12-month recall. Alfa ratings were assigned to 94.5%, 94.0%, and 91.5% of the restorations at baseline, 6 months, and 12 months, respectively. No statistically significant difference was found among any of the recall times.
TABLE 3  Net occlusal wear of Dyract AP restorations over 12 months

<table>
<thead>
<tr>
<th>Restorations</th>
<th>Mean (SD) wear (µm)</th>
<th>6 mo</th>
<th>12 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>21.2 (9.1)</td>
<td>39.0 (12.6)</td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td>16.1 (13.2)</td>
<td>33.3 (13.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>18.5 (11.7)</td>
<td>35.7 (13.6)</td>
<td></td>
</tr>
</tbody>
</table>

*Difference between 6 months and 12 months statistically significant (P < 0.001).

Wear performance

The mean wear values of the restorations, measured from the stone replica, are presented in Table 3. The average wear of material (adjusted for baseline) at the 6-month and 12-month recalls was 18.5 ± 11.7 µm and 35.7 ± 13.6 µm, respectively. This difference was statistically significant (P < 0.01).

Gingival status

The gingiva adjacent to all the Class II restorations were healthy at the 6-month and 12-month evaluations. No signs of gingival reaction or bleeding from periodontal probing were observed.

DISCUSSION

The compomer restorative system evaluated in this study uses simplified cavity-conditioning methods. Pretreatment of the cavity with NRC, which does not require rinsing after application and uses only 1 layer of bonding agent (Prime & Bond NT) simplified the treatment procedure considerably. With its components containing polymerizable double bonds, the NRC left on the cavity surface was believed to copolymerize with the subsequent bonding agent matrix. Prime & Bond NT was developed as a low-viscosity self-priming adhesive that is capable of penetrating the smear layer and infiltrating underlying dentin, instead of requiring removal of the smear layer by acid etching. The elimination of treatment steps with the use of this dental bonding system means that it is more user friendly. This would be particularly useful for treating children, because it saves treatment time and reduces the risk of moisture contamination.

Retention

For new hybrid restorative materials, like RMGICs or PMRCs, simplified cavity-conditioning methods (eg, self-etching primer systems) have been recommended. It has been reported that the bond strength of the PSA Prime/Adhesive (Dentsply DeTrey) used with Dyract is sufficient to provide adequate retention, while acid-etching of the enamel or use of a total acid-etch technique is not necessary. Besides the features of macromechanical retention of Class I and Class II preparations, the chemical adhesion of this compomer restorative may have helped to produce the excellent retention in this study. Dyract AP and Dyract compomer are claimed to form ionic bonds between hydrophilic phosphate groups of dipentaerythritolpentacrylate phosphonic acid and the calcium ions of hydroxyapatite. Moreover, the TCB resin in Dyract compomer, a new monomer formed by the reaction of butane tetracarboxylic acid and hydroxyethylmethacrylate, has methacrylate groups as well as carboxyl groups. The carboxylate (COOH) groups enable it to be self-adhesive.

According to recent laboratory studies, continuous and uniform hybrid layers have been observed between Dyract AP restorations and dentin that has been conditioned with NRC and Prime & Bond NT. A previous study also reported that a thin hybridlike structure could be observed between Dyract and dentin conditioned with PSA Prime/Adhesive. The micromechanical interlocking between Dyract AP and dentin might have also contributed to its excellent retention. Although clinical retention may be achieved with simplified conditioning methods for compomer restorations, whether acid etching of enamel will improve their marginal adaptation requires further clinical investigation.

Marginal discoloration

Modern light-cure composite restorative materials still fail in achieving perfect margins, although they may meet the requirements of esthetics and retention. Contraction stresses developed from shrinkage during setting lead to the formation of gaps between the restoration and cavity wall, and marginal leakage or staining may appear clinically thereafter. In this study, a gradual discoloration of the restoration margins was noted during the 1-year period, although this was clinically acceptable. Compared with the results of an earlier clinical study on Dyract, the marginal adaptation and sealing quality of Dyract AP seem to have improved. However, these properties were still inferior to those of resin composites. Marginal discoloration, which may influence the longevity of the bonds, still remains problematic and needs to be improved. Whether acid etching with 36% phosphoric acid gel would improve this situation is unclear and must be investigated further.
Recurrent caries

Signs of early caries in 3 Class II restorations were detected in the radiographs taken at the 1-year evaluation. However, it was difficult to ascertain that they were true secondary carious lesions because no loss of tooth structure was detected clinically and the discoloration was superficial. Close attention should be paid to these restorations, although they did not need additional treatment at that moment.

Replacement of compomer restorations because of secondary caries has been reported previously. Caries may develop adjacent to compomer restorations because of marginal leakage and subsequent carious processes.

On the other hand, it is generally believed that PMRCs have cariostatic properties, because an acid-base reaction is believed to take place, resulting in fluoride release when water is absorbed from the oral environment. This acid-base reaction, however, was reported to take place only briefly and superficially. Although these fluoride-releasing materials have been proposed for a wide variety of clinical applications, the clinically effective levels of fluoride release needed to withstand demineralization of enamel and dentin must be investigated.

Surface texture

The surface texture of the Dyract AP restorations in this study was evaluated clinically and indirectly from color slides and dental replicas. In agreement with results of previous studies on compomer, Dyract AP showed relatively smooth surfaces comparable to that of the adjacent enamel.

It has been reported that Dyract compomer exhibits surface characteristics between those of microfilled resin composite and ultrafine compact-filled resin composite and is significantly smoother than conventional GICs and RMGICs. The high polishability of Dyract is attributed mainly to its smaller particles. With a reduced mean particle size, Dyract AP exhibits better surface performance than did its precursor. The outstanding surface characteristics and color-matching ability of Dyract AP fulfill the esthetic requirement for anterior restorations.

Wear performance

The in vivo wear assessment indicated that this new-generation compomer has improved wear resistance. After 1 year, the mean wear value for the Dyract AP restorations was 35.7 µm, which is much lower than that of its earlier product (72.7 µm) and close to that of a resin composite (23.6 µm).

In this study, loss of material arising from abrasion and wear could not be detected in the direct clinical evaluations. The Rheinberger scale, which was used to estimate the mean wear values of the restorations in indirect evaluations, consists of a series of tooth-sized stone replicas with restoration-like incremental defects ranging from 25 to 1,000 µm. In this study, the wear of some 30 replicas taken at the 6-month recall were rated as 25 µm, although they showed loss of material less than that. Similarly, when the amount of wear of the restoration was between 2 values on the scale, the higher value was chosen. Thus, the real mean values of loss of occlusal material are probably less than those reported.

The modified organic matrix in Dyract AP, achieved by adding cross-linking monomer, and the reduced particle size of the glass in Dyract AP probably contributed to hardness and strength that were greater than those of its precursor and a wear resistance comparable to that of resin composite. The improved wear resistance of Dyract AP appears very promising, and these results strongly support its use in stress-bearing posterior teeth.

CONCLUSION

1. Dyract AP compomer exhibited wear resistance comparable to that of resin composite, suggesting that Dyract AP can be used in stress-bearing tooth areas.
2. The 1-year findings of this study showed that the clinical performance of Dyract AP restorative system was satisfactory.

Clinical investigations of longer duration are required to ascertain whether the material can be considered as an alternative to amalgam.

ACKNOWLEDGMENTS

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REFERENCES


Lab Manual of Normal Oral Histology

Holliston L. Riviere

This lab manual of color oral histology photographs is designed to aid dental and dental hygiene students in identifying the salient features of microscopic anatomy of oral tissues. It presents large, clear, identifiable photos of normal oral tissues and developing teeth accompanied by brief descriptions highlighting the special features of each.

Contents

Chapter 1 Tooth Development
Chapter 2 Enamel
Chapter 3 Dentin
Chapter 4 Pulp
Chapter 5 Cementum
Chapter 6 Periodontal Ligament and Dentogingival Junction
Chapter 7 Alveolar Bone
Chapter 8 Tooth Eruption and Shedding
Chapter 9 Mucosa
Chapter 10 Salivary Glands
Chapter 11 Temporomandibular Joint

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