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Clinical Performance and Wear Resistance of Two Compomers in Posterior Occlusal Restorations of Permanent Teeth: Six-Year Follow-up

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Clinical Relevance

The restoration quality has decreased and the wear increased for two compomers placed in the occlusal surface of permanent posterior teeth after six years; however, the restorations were clinically acceptable at the end of the evaluation.

SUMMARY

This study evaluated the clinical performance and wear resistance of compomer restorations placed in the occlusal cavities of posterior permanent teeth after six years. In 1999, 72 Class I restorations were placed by a single operator in 33 patients. Eighty-two percent of these restorations were located in molars. Each patient received at least two restorations, one with F2000 (3M ESPE) and another with Dyract AP (Dentsply). The finished and polished restorations that were free of any failure were considered the baseline. The restorations were clinically evaluated at baseline and at one-, two- and six-year intervals using modified USPHS criteria for color mismatch, marginal discoloration, surface roughness, marginal adaptation, anatomic form and secondary caries. Polyvinylsiloxane impressions (Express, 3M ESPE) were also taken, and models were obtained for indirect wear assessment (Leinfelder scale) at the same intervals. After six years, 11 patients attended the recall. Twenty-seven compomer restorations (11 with Dyract and 16 with F2000) were reevaluated. Data were submitted to the Friedman's test, ANOVA with repetitive measures, Tukey's test (clinical data), Wilcoxon and Kruskal-Wallis tests and the Spearman's correlation test (wear evaluation), all at a significance level of $p<0.05$. When comparing the materials, F2000 and Dyract pre-

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sented similar clinical performance and occlusal wear at the end of the clinical trial. The two compomers showed a significant increase in wear at the six-year follow-up, and a positive correlation (r^2=0.65) was detected between wear and evaluation time (p<0.001). Despite the decrease in restoration quality and the increase in occlusal wear, nearly all restorations were considered acceptable after the six-year evaluation.

INTRODUCTION

The current demand for aesthetic treatments and minimally invasive dentistry that avoids removal of healthy dental tissue increase the placement of adhesive tooth-colored restorations.[1] Currently, there is a vast range of adhesive materials available for clinicians and, according to a recent survey related to the longevity of posterior restorations, the improvement in materials technology and the reduction in cavity preparation will correlate to the selection of direct restorative materials instead of indirect restorations.[2]

Compomers or polyacid-modified resin composites are hybrid materials where resinous components have been added to glass ionomer cements to improve their mechanical properties and bond strength.[3-4] Compomers could overcome some of the limitations of glass ionomer cements, such as control curing time, low mechanical strength, unsatisfactory aesthetics and moisture sensitivity, and easy handling, which justifies their high popularity.[5] However, compomers do not present the traditional acid-base reaction observed for glass ionomer cements.[4] The wear resistance and mechanical properties of compomers are generally lower than that of composites,[3] but they release fluoride and therefore act as a fluoride reservoir, preventing demineralization and enhancing remineralization.[6]

Compomers show excellent performance in anterior teeth[7] and deciduous molars.[8-9] Their placement in ultraconservative cavities in permanent posterior teeth produced satisfactory results;[10] whereas, concerns remain regarding their application in stress bearing areas of posterior permanent teeth.[11]

Satisfactory restorations were observed after one year for F2000 and Dyract placed in occlusal cavities located in posterior permanent teeth.[12] Good results were observed in Dyract in small Class I cavities in permanent teeth after five years.[13] In addition, clinical evaluation of compomers in Class I and II restorations in permanent teeth showed good clinical performance.[5] Most studies have generally used the subjective criteria of USPHS to qualitatively evaluate the clinical performance of these materials,[8,10,12] while a few studies have used the quantitative measurements of occlusal wear,[5] which is extremely relevant, considering posterior teeth.[14] The majority of these studies were limited to a three-year follow-up, but the real clinical performance of a restorative material should only be determined after a significant length of time, which is critical for restoration durability[2,15] in the inhospitable oral environment.[16-17]

This study aimed to qualitatively evaluate the clinical performance (USPHS criteria) and quantitatively evaluate the occlusal wear (Leinfelder scale) of Class I restorations performed with two different compomers in permanent teeth after a six-year follow-up.

METHODS AND MATERIALS

Patients Selection: In 1999, 33 patients (average age of 25 years) requiring occlusal Class I restorations were selected at the post-graduate clinic of the Federal University of Pelotas (Brazil). This study was approved by the local Ethics Committee (document n° 31/05). The criteria for patients' inclusion in the study included at least two Class I occlusal restorations in posterior permanent teeth, with the cavities not being larger than one-third of the intercuspid distance. The exclusion criteria included patients presenting with posterior tooth loss, those with prosthesis and patients with parafunctional habits. A written consent from each participant was obtained prior to commencement of the clinical procedures. The participants were free to withdraw from the trial without justification at any stage of the evaluation. The restorations were evaluated by modified USPHS criteria at baseline, one year, two years and six years by one calibrated blind examiner.

Clinical Procedures: The experiment was conducted as previously described[12] and clinical procedures are briefly presented here. Class I occlusal cavities were prepared with a conservative design restricted to caries or failed restoration removal. All restorations were placed using rubber dam isolation. In deep cavities, calcium hydroxide cement (Hydro C–Dentsply, Petrópolis, RJ, Brazil) was applied. Seventy-two cavities were prepared in molars and premolars. Both materials were applied in the same patient, and they were randomly allocated between upper and lower posterior teeth. Each patient received at least two restorations, one with F2000 and another with Dyract. All restorations were placed after 35% phosphoric acid etching (Dentsply, Petrópolis, RJ, Brazil) and Prime & Bond 2.1 (Dentsply) or Single Bond (3M ESPE, St Paul, MN, USA) were applied for Dyract and F2000, respectively. An XL 3000 light curing unit (3M ESPE) was used, with irradiance ≤450 mW/mm^2, which was constantly tested by a built-in radiometer. Finishing and polishing procedures were carried out as previously described.[12] Only one operator placed all the restorations.

Clinical Evaluation: The polished restorations were initially evaluated according to modified USPHS (United States Public Health Service),[18] and only those

exhibiting Alpha classification in all criteria were included in the study at baseline.[12] The clinical evaluation at all periods of evaluation was based on the following criteria: anatomic form, marginal discoloration, color match, marginal adaptation, surface roughness and the presence of secondary caries.

Wear Evaluation: Impressions were taken with polyvinylsiloxane silicone impression material (Express, 3M ESPE) at the follow-up periods investigated in the clinical evaluation. Models of the Leinfelder scale were used to perform the visual readings of the wear, comparing them with the gypsum models obtained from the impressions of the compomer restorations. For standardized models, the Leinfelder scale was composed of different simulated wear in occlusal cavities: 0 µm, 25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800 and 900 µm. The occlusal surface of each tooth was divided into four parts (quadrants); the higher wear found in each part was noted, and an average wear value was obtained for each tooth. One blind examiner performed the indirect evaluation, without information about the material used in each case.

At the first recall (1-year), 25 patients with 52 restorations returned and, at the second recall (2-year), 21 patients with 42 restorations were evaluated. In 2005, at the end of the clinical trial (6-year), 11 patients (average age= 27 years, ranging from 18 to 37 years) attended the recall (recall rates of 75%, 63% and 33% for one-, two- and six-years, respectively). Twenty-five restorations were evaluated in molars (12 upper and 13 lower) and two in premolars (1 upper and 1 lower).

Clinical evaluation data were submitted to statistical analysis using Friedman's test, ANOVA with repetitive measurements and Tukey's test. The comparison of wear (Leinfelder scale) between both compomers was carried out with Wilcoxon Signed Rank Test. The nonparametric Kruskal-Wallis test was used to compare the different follow-up periods. The statistical software used for the statistical analysis was SigmaStat 3.01 (SPSS Inc, Chicago, IL, USA), Windows statistical package. All tests were performed at the $p<0.05$ level of significance. The relationship between clinical wear and time was evaluated using Spearman's correlation in all evaluated recalls.

RESULTS

In Table 1, the findings of the evaluated restorations for different criteria are observed for the different periods. Only those restorations evaluated in the three recalls periods were included in the analysis. A significant deterioration in restoration quality for both materials was observed in most of the criteria, with a higher rate of Beta codes at the last evaluation ($p<0.05$). However, all of the restorations made with F2000 were acceptable, and only one restoration of the Dyract group was considered unsatisfactory (C in anatomic form).

At the six-year recall, there were no significant differences between materials in terms of color match, secondary caries, surface roughness and marginal discoloration. The anatomic form remained similar for F2000 during the study, but there was a significant decrease in this criteria for Dyract restorations ($p<0.05$), with one restoration classified as unsatisfactory due to poor anatomical form (code C). However, there was no significant difference between both materials in these criteria.

Table 1: *Results of Clinical Evaluation of Compomer Restorations (%) at 1-, 2- and 6-year Evaluations, According to Modified USPHS Criteria*[18]

Criteria	Code	1-year		2-year		6-year	
	(*)	F2000	Dyract	F2000	Dyract	F2000	Dyract
Color Match	*A*	11 (64.7)	6 (50)	11 (64.7)	6 (50)	9 (52.9)	3 (25)
	B	6 (35.3)	6 (50)	6 (35.3)	6 (50)	8 (47.1)	8 (66.7)
	C	0	0	0	0	0	1 (8.3)
Marginal	*A*	12 (70.6)	4 (33.3)	12 (70.6)	4 (33.3)	0	1 (8.4)
Adaptation	*B*	5 (29.4)	8 (66.7)	5 (29.4)	8 (66.7)	17 (100)	11 (91.6)
	C	0	0	0	0	0	0
Anatomic Form	*A*	15 (88.2)	8 (66.6)	15 (88.2)	8 (66.6)	14 (82.3)	1 (8.4)
	B	2 (11.8)	4 (33.4)	2 (11.8)	4 (33.4)	3 (17.7)	10 (91.6)
	C	0	0	0	0	0	1
Surface Roughness	*A*	1 (5.9)	11 (91.7)	0	10 (83.3)	0	6 (50)
	B	16 (94.1)	1 (8.3)	17 (100)	2 (16.6)	17 (100)	6 (50)
	C	0	0	0	0	0	0
Marginal	*A*	15 (88.2)	12 (100)	14 (82.3)	11 (91.7)	9 (52.9)	5 (41.7)
discoloration	*B*	2 (11.8)	0	3 (17.7)	1 (8.3)	8 (47.1)	7 (58.3)
	C	0	0	0	0	0	0
Secondary Caries	*A*	17 (100)	12 (100)	17 (100)	12 (100)	17 (100)	12 (100)
	B	0	0	0	0	0	0

(*)Codes A=Alpha; B=Bravo; C=Charlie

Table 2: *Means of Occlusal Wear (µm) for Both Compomers in Different Follow-up Intervals, Using the Leinfelder Scale*

		Follow-up	
Material	**1-year**	**2-year**	**6-year**
F2000	[A]13.1(±11)a	[B]29.5(±16.6)b	[C]65.9(±52.5)c
Dyract	[A]11.9(±16)a	[B]25(±20.8)b	[C]46.3(±25.2)c

**the same small letters following means indicate similar occlusal wear for the compomer in the different periods of time evaluated.*

***the same capital letters preceeding means indicate similar occlusal wear between both materials in each period of time.*

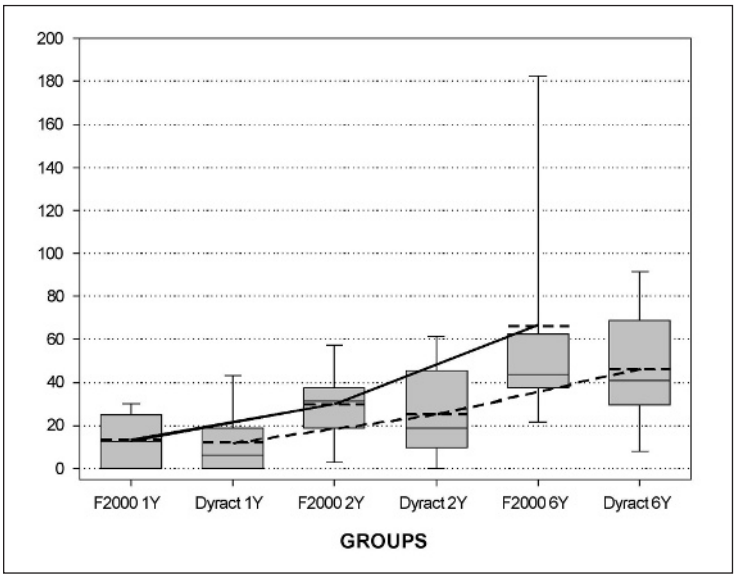

Figure 1. *Box-plot graph illustration showing increased wear for both compomers over the time period. The dotted line inside each box represents the mean value for each restorative material connected by a line.*

The occlusal wear measured with the Leinfelder scale significantly increased with restoration age ($p<0.05$) (Table 2, Figure 1), and a significant ($p<0.001$) positive relationship ($r^2=0.65$) was detected using the Spearman's correlation test. No significant difference in terms of occlusal wear was observed between materials in the three recalls ($p>0.05$).

DISCUSSION

Despite being regarded as outstanding evidence in the evaluation of medical technologies and health care interventions, large, randomized, controlled clinical trials may be infeasible mainly due their high costs.[19] Another problem with clinical trials is the dropout rate of the patients during the study, which could compromise the external validity of the findings. This problem was observed in this study, with a reduction from 33 patients at baseline to 11 patients after six years. The low number of restorations present at the final evaluation made it difficult to detect potential differences between materials.

A rigid protocol was established at the beginning of this study in terms of patients' inclusion and exclusion, research team, patients and materials. These characteristics enhance the validity of the study, reinforcing the relevance of the findings observed. In addition, no other study has evaluated the clinical performance of compomers in posterior teeth for such a long period of time.

The USPHS criteria used in this study is based on a subjective evaluation; however, this methodological approach has also been intensely used to evaluate the clinical performance of dental materials.[20] In this study, such qualitative analysis was also associated with a quantitative analysis (Leinfelder scale).[14]

The clinical service had affected both materials and, with aging, it could be observed that an increased number of restorations presented a reduction in their quality. This fact was previously observed, with a positive correlation between the quality of the restorations and follow-ups.[1-2] In the oral cavity, degradation is a common process that includes disintegration and dissolution of materials in saliva and other types of chemical/physical degradations caused by occlusal loading, masticatory forces, temperature challenges and enzymatic attack and pH changing.[16] In addition, clinical failures are more prone to occur when the materials are placed in stress-bearing locations.[1-2] Despite the decrease in restoration quality along the elapsed time, nearly all the restorations were classified as satisfactory at the end of the clinical trial. As a confirmation of this result, a low annual failure rate for compomer in posterior permanent teeth was detected.[2]

A decrease in restoration quality was observed, with most restorations changing from an Alpha (ideal) to a Beta (acceptable) classification in the USPHS criteria. Both materials showed a rougher surface with aging, mainly due to friction with food and antagonist teeth during mastication.[16] A slight color mismatch was observed after six years, which could be related to pigment absorption from dietary habits.[17] Also, a reduction in marginal adaptation was detected, with a slight crevice along the marginal interface in all the restorations evaluated. This was probably due to fracture of the overlapping fine type marginal excess that originated in a ledge that caught the explorer during the recall evaluation.[1] More stained cavosurface margins were observed with aging, which might be a result of the degradation potential of the hydrophilic adhesive systems.[21] In this study, the restorations were placed after acid etching, and fifth-generation dentin adhesive systems were used for both compomers. Such a clinical approach can improve the marginal sealing and adap-

tation of compomer restorations.[22] Anatomic form alterations were observed during the clinical study, especially for Dyract after six years. Although compomers are improved materials when compared to glass ionomer cements or resin-modified glass ionomer cements, they have still lower mechanical properties, such as wear resistance, when compared to modern resin composites.[3,23] Even longer periods of clinical evaluation showed no significant changes in anatomical form for composite restorations,[1] and this better performance should be related to the higher amount of fillers present in composites compared to compomers.[23] No case of secondary caries was detected in this study. Instead of the potential fluoride release from these materials, the reason to justify such a finding is that the patients who enrolled in the clinical trial received educational training towards an oral health promotion.

During the quantitative evaluation, it was clearly noticed that occlusal wear increased with aging. This fact can be easily explained by several factors, such as the constant food attrition, chewing forces, antagonist teeth, tooth brushing habit and frequency, ingestion of acidic foods and drinks, gastric disorders and material composition.[13,23] Frequent submission of the restorative material to masticatory stress will result in the material's fatigue and, as observed in this study, with a longer follow-up period, deeper occlusal wear will be observed.[5] When comparing both compomers, there was no significant difference after six years in terms of occlusal wear and, except for one Dyract restoration, the occlusal wear average after six years was not sufficient to require replacement of the restorations according to ADA guidelines.[24]

The six-year findings for compomers placed in the stress–bearing occlusal cavities of permanent teeth were promising, corroborating the findings of previous studies.[5,10,15] Other investigations, including a higher number of restorations and a comparison of these restorations with other materials, including resin composites, should be performed to confirm these preliminary results. It could be hypothesized that, in terms of restoration longevity, the better mechanical properties of composites may represent an advantage in relation to compomers. Nevertheless, the good performance observed in permanent teeth seems to be an indication that compomers could reveal improved performance in deciduous molars,[8-9] as well as for other purposes, such as fillers for fixed prosthodontics tooth preparations, liners, bases, repair of restorations, cements and pit and fissure sealants.

CONCLUSIONS

Within the limitations of this study, it could be concluded that:

1. Both compomers performed similarly, and they provided acceptable results as a posterior restorative material in stress-bearing areas after six years.
2. Aging has a significant effect on materials, decreasing the quality of restorations (USPHS criteria) and increasing their wear (Leinfelder scale).

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