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Clinical Behavior of Dental Restorations Made with Compomers, Comparing with Composite and Glass Ionomers

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Abstract: *Compomers have emerged by modifying dental composites in an effort to combine their desired properties, namely their good aesthetics, with those of glass ionomer cements, namely their ability to release fluoride for a long time. While this combination of good aesthetics and fluoride release may seem to give compomers an advantage, their poor mechanical properties limit their use. The main components of the compomers are polymerizable dimethacrylate resins, such as urethane dimethacrylate and TCB (a butantetracarboxylic acid reaction product) and hydroxyethyl methacrylate and ionizable glass fillers, such as fluorosilicate glass.*

Keywords*: compomer, composite, glass ionomer cement*

1. Introduction

The etymology of the word *compomer* derives from: *compo*- from the structure *composite resins* and *-mer* from *glass ionomer*, in order to highlight and particularize and by name this new generation of biomimetic physiognomic restoration materials.

Attempts to modify the dental materials used in filling cavities aimed to find a product that was as close as possible to an ideal filling material, which should meet the following properties [1-3]: easy to use; identical color to the tooth; adhesion to the dental hard substance (enamel and dentin); without volumetric changes after application; to provide protection against recurrent caries; have adequate strength; to be insoluble and non-corrodible in the oral cavity; to have a low capacity to absorb oral fluids; not be toxic to dental pulp and gingival tissue; to be able to polish without difficulty; not to potentiate the formation of bacterial plaque on their surface; to have a wear rate similar to that of tooth enamel; to have a coefficient of thermal expansion similar to that of enamel and dentin; to be radio-opaque; to be affordable. All these requirements are not yet found in any existing restorative material, each material, through its physical, chemical and biological properties, trying to get as close as possible to an ideal filling material.

Compomers are essentially composites, in the sense that they are composed of a resin and a filler. After placing the material in the cavity, the initial setting reaction is initiated by light as in the case of composite resins.

In 1993 Dentsply introduced Dyract as the first compomer, with the following properties [4, 5]: a combination of double-functional monomers and acid-reactive glass; light curing; confirmed acid-base reaction, which leads to the release of fluorine after insertion into the cavity, but which is not responsible for the curing reaction; without water content (water-free material). The compomer material fixed in the carious cavity receives water from the saliva, which causes the dissolution of metal ions and a cross-linking of the matrix by forming a bridge between the carboxyl groups (-COOH) and the metal ions.

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For the compomers, a new monomer was created which contains in addition to the two polymerizable methacrylate groups and an acid group similar to the glass ionomer polymer [5]. The light curing of the compomers (initiated by the light beam) corresponds to the reactions present in the composites, by the initiation of the polymerization reaction by a photo initiator. In addition, the compomer also combines acidic groups in the same monomer, respectively the same monomers based on the double composition also contain carboxyl groups [5-7]. Because compomers are water-free materials, these carboxyl groups are inactive until after the restoration is placed in the oral cavity. This acid-base reaction is very slow compared to the setting reaction, which takes place under the influence of light. Soaking (saturation) the filling with water triggers the acid-base reaction which is insignificant for hardening the material, but is important for fluoride positioning and lasts for several months, and the absorption of water in the filling until saturation depends on the size of the restoration [4, 5, 7].

In the present study we aimed to evaluate the clinical behavior of fillings made with composite materials, compared to that of coronary restorations of composites and glass-ionomers, in order to evaluate the advantages and disadvantages of this new subclass of physiognomic filling materials.

2. Materials and methods

2.1. Materials

The clinical study was conducted over a period of 3 years, between 2016-2019 and included a number of 78 patients aged between 10-59 years, 35 females and 43 males, in whom were made 228 direct restorations, from the materials presented in Table 1.

Two light-cure compomers from Dentsply were studied: Dyract AP, second generation compomer and Dyract Extra, third generation compomer. These compomers were used in conjunction with Dentsply's Prime & Bond NT adhesive, the recommended adhesive for them, and the same company's Xeno III adhesive.

From the class of composites, Kerr's Point 4 was studied, a microhybrid composite, light-curable together with its own OptiBond Solo Plus adhesive.

From the class of glass-ionomers were studied: Kavitan plus, self-curing glass ionomer of Spofa and Ketac molar, self-curing glass-ionomer of 3M ESPE.

Table 1. Distribution of restorations by types of cavities and materials used

Type of restored carious cavities	Materials used for restoration				
	Dyract AP	Dyract Extra	Point 4	Kavitan plus	Ketac molar
Class I	17	22	19	10	12
Class II	15	8	14	0	8
Class III	16	14	12	5	8
Class IV	4	4	4	0	0
Class V	4	9	4	9	10
Total	56	57	53	24	38
Total direct restorations	228				

For all these filling materials, the instructions for use of the manufacturing companies were strictly observed [4, 5, 8-11]. Kerr Life's calcium hydroxide self-curing pulp protection was also made.

Patients were followed and examined at regular intervals: 3 months, 6 months, one year, two years, and at the end of three years after restorations. The changes in these restorations were tracked and quantified according to the criteria of the US Public Health Service - USPHS criteria - which try to quantify the significant changes in restorations applied in the oral cavity [12-14]. These criteria cover nine aspects: ability to match color; marginal secondary caries; the need for replacement / loss of restoration; marginal area pigmentation; marginal integrity; anatomical shape - preservation or loss of morphology; surface texture - rough or fine; postoperative sensitivity; restoration lifetime. These criteria are measured by a system of points or performance levels: A (Alpha) - clinically ideal; B (Bravo) - clinically acceptable and C (Charlie) - clinically unacceptable.

3. Results and discussions

Each of the 9 parameters was followed at the clinical controls of each patient in the study. The evaluation of the USPHS criteria for each of the clinically tested materials was performed based on the consultation sheets, the results being listed in Tables 2-6.

Table 2. Clinical behavior of Dyract AP compomer restorative material

No.	USPHS criteria	Dyract AP (Dentsply) 56 restorations				
		3 months	6 months	12 months	24 months	36 months
1.	ability to match color	45 A 11 B	45 A 11 B	41 A 12 B 1 C	38 A 13 B 1 C	36 A 14 B 1 C
2.	marginal secondary caries	56 A	56 A	50 A 4 B	48 A 4 B	45 A 6 B
3.	the need for replacement / loss of restoration	0	0	2	4	5
4.	marginal area pigmentation	56 A	55 A 1 B	50 A 4 B	47 A 5 B	45 A 6 B
5.	marginal integrity	56 A	55 A 1 B	50 A 4 B	44 A 6 B 2 C	44 A 5 B 2 C
6.	anatomical shape - preservation or loss of morphology	55 A 1 B	54 A 2 B	43 A 4 B	40 A 5 B	40 A 5 B 6 C
7.	surface texture - rough or fine	50 A 6 B	50 A 6 B	44 A 8 B 2 C	40 A 10 B 2 C	39 A 10 B 2 C
8.	postoperative sensitivity	56 A	56 A	54 A	52 A	50 A 1 B
9.	lifetime of restorations, %	100	100	96.42	92.85	91.07

Table 3. Clinical behavior of Dyract Extra compomer restorative material

No.	USPHS criteria	Dyract Extra (Dentsply) 57 restorations				
		3 months	6 months	12 months	24 months	36 months
1.	ability to match color	48 A 9 B	47 A 9 B	45 A 9 B 1 C	44 A 8 B 1 C	42 A 8 B 3 C
2.	marginal secondary caries	57 A	56 A	50 A 5 B	47 A 6 B	46 A 6 B 1 C
3.	the need for replacement / loss of restoration	0	1	2	4	4
4.	marginal area pigmentation	57 A	50 A 6 B	48 A 6 B 1 C	46 A 4 B 1 C	44 A 5 B 4 C
5.	marginal integrity	52 A 5 B	50 A 5 B	47 A 7 B 1 C	47 A 5 B 1 C	43 A 6 B 4 C
6.	anatomical shape - preservation or loss of morphology	53 A 4 B	47 A 8 B	45 A 8 B 2 C	45 A 6 B 2 C	44 A 6 B 3 C
7.	surface texture - rough or fine	52 A 5 B	48 A 7 B 1 C	47 A 7 B 1 C	47 A 5 B 1 C	46 A 4 B 3 C
8.	postoperative sensitivity	54 A 3 B	52 A 4 B	50 A 5 B	47 A 6 B 1 C	47 A 5 B
9.	lifetime of restorations, %	100	98.24	96.49	92.98	92.98

Table 4. Clinical behavior of composite restoration material Point 4

No.	USPHS criteria	Point 4 (Kerr) 53 restorations				
		3 months	**6 months**	**12 months**	**24 months**	**36 months**
1.	ability to match color	50 A 3 B	50 A 2 B	47 A 3 B	45 A 2 B	42 A 3 B 3 C
2.	marginal secondary caries	53 A	51 A 1 B	47 A 3 B	41 A 6 B 1 C	40 A 6 B 2 C
3.	the need for replacement / loss of restoration	0	1	3	5	5
4.	marginal area pigmentation	51 A 2 B	51 A 1 B	45 A 5 B	40 A 6 B 2 C	39 A 6 B 3 C
5.	marginal integrity	51 A 2 B	48 A 4 B	45 A 5 B	40 A 6 B 2 C	39 A 6 B 3 C
6.	anatomical shape - preservation or loss of morphology	50 A 3 B	47 A 5 B	44 A 4 B 2 C	41 A 5 B 2 C	38 A 6 B 4 C
7.	surface texture - rough or fine	51 A 2 B	47 A 5 B	43 A 5 B 2 C	40 A 6 B 2 C	38 A 7 B 3 C
8.	postoperative sensitivity	53 A	50 A 2 B	48 A 2 B	44 A 4 B	44 A 4 B
9.	lifetime of restorations, %	100	98.11	94.33	90.56	90.56

Table 5. Clinical behavior of Kavitan Plus glass ionomer restorative material

No.	USPHS criteria	Kavitan Plus (Spofa) 24 restorations				
		3 months	**6 months**	**12 months**	**24 months**	**36 months**
1.	ability to match color	18 A 6 B	17 A 6 B	15 A 5 B 1 C	15 A 3 B 1 C	11 A 3 B 3 C
2.	marginal secondary caries	24 A	21 A 2 B	16 A 4 B 1 C	14 A 4 B 1 C	12 A 3 B 2 C
3.	the need for replacement / loss of restoration	0	1	3	5	7
4.	marginal area pigmentation	24 A	21 A 2 B	16 A 3 B 2 C	14 A 3 B 2 C	11 A 5 B 1 C
5.	marginal integrity	24 A	20 A 3 B	17 A 3 B 1 C	14 A 3 B 2 C	11 A 4 B 2 C
6.	anatomical shape - preservation or loss of morphology	20 A 4 B	19 A 2 B 2 C	16 A 2 B 3 C	14 A 3 B 2 C	10 A 3 B 4 C
7.	surface texture - rough or fine	18 A 6 B	16 A 6 B 1 C	15 A 4 B 2 C	14 A 5 B	10 A 3 B 4 C
8.	postoperative sensitivity	21 A 2 B	20 A 3 B	18 A 3 B	15 A 2 B 2 C	13 A 3 B 1 C
9.	lifetime of restorations, %	100	95.83	87.50	79.16	70.83

Table 6. Clinical behavior of Ketac Molar glass ionomer restorative material

No	USPHS criteria	Ketac molar (3M ESPE) 38 restorations				
		3 months	**6 months**	**12 months**	**24 months**	**36 months**
1.	ability to match color	25 A 11 B 2 C	22 A 10 B 3 C	20 A 10 B 3 C	18 A 10 B 4 C	17 A 9 B 5 C
2.	marginal secondary caries	38 A	35 A	30 A 3 B	20 A 10 B 2 C	19 A 9 B 3 C

3.	the need for replacement / loss of restoration	0	3	5	6	7
4.	marginal area pigmentation	37 A 1 B	32 A 3 B	30 A 3 B	28 A 3 B 1 C	26 A 4 B 1 C
5.	marginal integrity	35 A 3 B	30 A 3 B 5 C	30 A 3 B	27 A 3 B 2 C	25 A 5 B 1 C
6.	anatomical shape - preservation or loss of morphology	30 A 8 B	27 A 6 B 2 C	27 A 3 B 3 C	26 A 4 B 2 C	22 A 5 B 4 C
7.	surface texture - rough or fine	30 A 8 B	28 A 7 B	27 A 6 B	25 A 7 B	22 A 7 B 2 C
8.	postoperative sensitivity	35 A 3 B	32 A 2 B	30 A 3 B	27 A 6 B	26 A 6 B
9.	lifetime of restorations, %	100	92.10	86.84	84.21	81.57

The longevity of direct fillings (failure rate, average survival time) is the parameter that gives the dentist and the patient confidence in a certain type of material, respectively class of materials for dental fillings.

If we compare the lifespan of different restorations, the composites and compomers studied have a similar behavior over time, superior to glass ionomer cements (Figure 1).

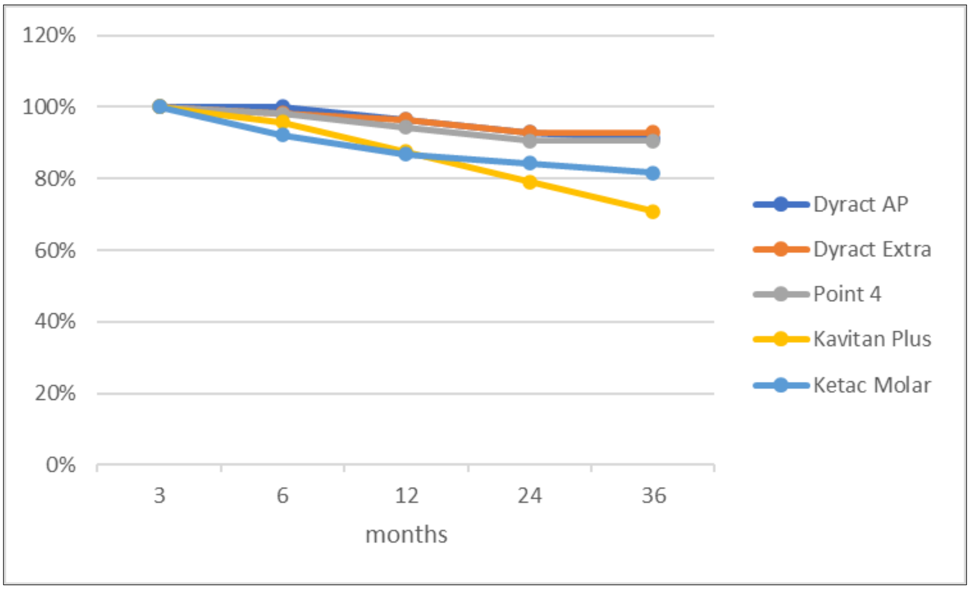

Figure 1. Lifetime of direct restorations

The chromatic stability of compomers and composite resin restorations is good and is maintained over time due to the addition of inorganic pigments in the resin and the achievement of particular shades according to the Vita key and the balancing of the refractive indices of the matrix with those of the coupling agent and those of filler particles [15]. The surfaces of glass ionomers, by the fact that they cannot be polished and by wear over time, determine a higher impregnation, which leads to a more accentuated chromatic alteration than to compomers or composites [16, 17].

Secondary caries is the main cause of restoration defects, especially in the posterior teeth, where they often evolve rapidly [12, 18]. Regarding the occurrence of secondary caries, in addition to the method of direct clinical evaluation, radiological examination in the retroalveolar or bite-wing incidence is also required. Secondary caries occurs along the proximal and cervical edges, because in these areas the thickness of the enamel is small and the orientation of the enamel prisms is unfavorable to an efficient acid treatment, access is difficult and the material is subjected to bending forces [19, 20].

An unfavorable evolution can be observed in restorations with compomers made by the method without acid etching, due to a possible weaker adhesion to the enamel-restoration interface, as well as due to the higher stress produced by occlusal forces due to the higher volume of restorations made with this material [21].

Marginal staining is due to marginal percolation of chromatogen products, that may be difficult to remove or not at all. The most important factor that prevents the appearance of marginal discoloration is the strong adhesion of the material to the edges of the cavity [22]. Other factors responsible for the appearance of marginal staining are the abrasion or fracture of the material at the border with the enamel, as well as the finishing procedures that must be performed extremely carefully so as not to fracture the border between restoration with the enamel wall [23].

Another cause of marginal discoloration is shrinkage during curing, if the restoration mass is large or if it is not applied correctly [24, 25]. In compomers this contraction is compensated by the absorption of water which triggers the acid-base reaction and causes the release of fluorine, but is not responsible for the curing reaction of the material as in the case of glass ionomers [4, 5, 26].

The low level of marginal integrity of glass ionomers is also explained by the absorption of water after the insertion of restorations which, in the case of these materials, causes the weakening of the marginal wall [27, 28]. In the case of composites, the absorption of water determines an expansion after curing that combats the contraction and implicitly reduces the marginal infiltration and prevents the fracture of the thin walls from the edges of the restorations [29]. In the case of compomers, this water absorption determines the base-acid reaction, through which fluoride is released and there is an increase in the volume of the restoration with the fight against marginal percolation to which is added wear through the process of mastication or aging of the restoration [5, 30].

Loss of anatomical shape is a very important criterion in the case of restorations with physiognomic materials, especially in the lateral areas. Physiognomic restoration materials have two mechanisms of wear: abrasion and attrition [31]. The abrasion coefficient of each material depends on the inorganic filling, the size and distribution of the particles. An effect on the abrasion of surfaces in crown restoration materials can also have the air inclusions, both superficial and deep in the restoration mass, which can accelerate the processes of microcracks, the fracture ultimately contributing to the process of wear [32, 33]. Incomplete polymerization can also cause a decrease in wear resistance. In the study of Geurtsen and collaborators, it is pointed out that salivary esterases cause a decrease in wear resistance and hardness of compomers [34]. Using only inspection, most clinicians rate A for loss of restoration substance up to 150-175 microns (invisible to the naked eye), the maximum loss accepted by the ADA for a direct restoration composite being 200 microns in 3 years [35, 36].

In some restorations, clinically unsatisfactory levels of sensitivity to thermal agents (hot/cold), appear, which can be correlated with the phenomenon of lack of marginal continuity [37].

The loss of fillings has several causes and is due to the composition, the stress to which they are subjected, as well as the fatigue of the materials due to the physicochemical and mechanical conditions to which they are exposed in the oral cavity [38]. The causes of failure are: fracture of restorations, accentuated wear or marginal dyschromia, due to marginal microfractures [39, 40].

4. Conclusions

Clinical trials are indispensable for assessing the qualities of dental fillings. The criteria by which we evaluated the clinical behaviors of the restorations included in our study were those of the USPHS system - of the United States Health Service [13].

Ability to match color. The color is very well made for composites and compomers, in the composition of the resin being inorganic pigments, mainly metal oxides that perform well the nuance of materials in Vita colors, with shades of opaque and enamel. The studied composite had the best ability to maintain color throughout the study, but also the Dyract Extra compomer showed a positive evolution close to that of the composite. The Dyract AP compomer had a lower evolution than Dyract Extra and

Point 4 composite, but superior to the studied glass ionomers, which have a more translucent structure, having shades closer to dentin. Due to the impossibility of adequate finishing and to the wear, the chromatics of the fillings in the glass ionomers suffer.

Secondary caries. Dyract AP showed the lowest level of damage due to secondary caries, due to its balanced composition and the release of fluoride after curing and due to the absorption of water that triggers the base-acid reaction. Due to the more limited indication of use of Dyract AP fillings, this material is less exposed to occlusal trauma and marginal fractures. Dyract Extra and Point 4 composite showed a higher level of damage due to secondary caries, at comparable levels, the main causes of failure being a poor adhesion to the proximal limits of the restoration, to which also contributes the curing contraction and the high volume of fillings in extended cavities. The level of damage caused by secondary caries in restorations with Dyract AP, Dyract Extra and Point 4 is at clinically acceptable levels and in accordance with studies in the literature. The glass ionomers used had the highest values of damage due to secondary caries due to abrasion, dissolution of the material at the boundary with the enamel, which leads to the conclusion that these glass ionomers are a risky option to be used in cavities with occlusal stress.

Marginal dyschromia. The damage by marginal staining is closely related to the sealing capacity of the material at the border with the enamel, to the degree of surface roughness and to the microinfiltration capacity with various substances of the dental filling material. The Point 4 composite, due to the high degree of finishing, achieved the lowest level of damage by marginal staining. The next material was Dyract AP, followed by Dyract Extra which showed a higher degree of discoloration at the level of fillings made without acid demineralization. Adhesion without enamel demineralization has optimal levels in the first periods, but over time the value of adhesion decreases, which allows a greater marginal infiltration. The studied glass ionomers showed the highest values of marginal dyschromia due to possible marginal microfractures and due to a high absorption capacity of chromatogenic factors present in the oral cavity.

Marginal integrity. It must be correlated with the composition and mechanical properties of the filling materials that determine the strength of the thin walls at the edges of the dental restorations. The Point 4 composite, due to its very good mechanical properties, also had the lowest level of marginal fracture damage of the restorations performed. The next level was occupied by Dyract Extra which, due to its superior mechanical properties compared to Dyract AP, performed better in terms of loss of marginal integrity. The glass ionomers Ketac Molar and Kavitan Plus showed the most damage to the integrity of the marginal wall.

Anatomical shape. The best performance levels of this parameter were achieved by the Point 4 composite by its high inorganic loading and its optimal distribution in the resin mass. Dyract Extra also had a good evolution due to the much-improved composition compared to Dyract AP. Dyract AP had much lower wear and shape changes compared to Ketac Molar and Kavitan Plus which have the highest level of wear.

Surface texture. It is closely related to the anatomical shape, the finishing process and the way each material degrades due to abrasion and attrition. Point 4 composite material recorded the best clinical levels of surface texture. Dyract Extra due to the size of the filler particles and due to lower mechanical properties, has a lower level of performance. He was followed by Dyract Ap. The latest in performance are Ketac Molar and Kavitan Plus. The study showed that the compomers managed to reduce the disadvantages of glass ionomers in terms of surface texture.

Postoperative sensitivity. Through mechanical, thermal and chemical traumas, the dental structures after restoration can present clinical phenomena of sensitivity that disappear in time or determine the negative evolution of the restored dental structure. This sensitivity depends on the size of the prepared cavity, the way it is prepared and prepared, as well as the chemical trauma represented by acid demineralization and the application of dental fillings at the end of the study, Dyract AP showed the lowest level of postoperative sensitivity. Due to the design of the cavities and the low thermal conductivity, it had very good results. The next material was Point 4, followed by Dyract Extra. The higher level of sensitivity may be correlated with the higher volume of dentin and enamel excavated in the lateral area. The sensitivity recorded at glass ionomers cannot be fully correlated with the phenomenon of postoperative sensitivity, but can be associated with a more accentuated marginal micro-infiltration or with the phenomenon of fracture and secondary caries.

Loss of restoration / Need for replacement / Lifetime of restorations. The Dyract Extra compomer had a survival rate of 92.98% with four lost dental fillings, a survival rate that recommends it as viable for wider use. At Dyract AP, the survival rate of 91.07 shows that we can use this material only in strict compliance with the indications for the side area. At the Point 4 composite, the success rate was high and in accordance with the data from the specialized literature, reconfirming the value of this universal composite. The studied glass ionomers had lower success rates: Ketac Molar of 81.57% which requires caution in its use in the lateral areas, and the Kavitan Plus success rate of 70.83% recommends it as a material usable only in the area without occlusal stress or under composites and amalgam restorations.

The advantages of the studied compomers are: easy to handle; does not adhere to instruments; it condenses acceptably; presents good color stability over time; good adhesion to dental tissues (when acid demineralization is performed).

The disadvantages of the studied compomers are: high price; more accentuated wear in the cavities subjected to an intense occlusal stress compared to the studied composite; 3rd and 5th grade cavities where acid etching is not used can cause problems with marginal closure or marginal discoloration.

The compomers manage to eliminate some of the disadvantages of the material classes from which they come, but the instructions for use in the case of dental fillings in the posterior areas must be strictly observed.

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