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Correction of the State of Enamel Mineral Metabolism in Persons with Decompensated Caries at Various Times after Oral Cavity Sanitation

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Abstract

The aim of the study was to determine the effectiveness of brushite exposure to correct the marginal permeability of composite restorations in persons with a decompensated form of carious process activity; this study also examined the penetrating ability of brushite in the micro-cracks of the enamel-composite border.

Methods and Results: The study included 120 patients (age 18-40 years) with a decompensated course of the carious process, who underwent complete oral cavity sanitation with the direct composite restoration of 300 teeth. The obtained results were analyzed and interpreted in vivo (the clinical effectiveness of the restoration was assessed according to the Ryge criteria immediately after treatment and 1, 12, and 36 months after treatment) and in vitro (scanning electron microscopy of the enamel-composite joint after applying the composite and after treatment with the studied means). According to the purpose and objectives of the study, two groups of patients were formed: Group 1 (control, n=58): the prevention of recurrent caries after sanitation was carried out using a standard personal hygiene product containing fluorine; Group 2 (experimental, n=62): the prevention of recurrent caries after sanitation was carried out using a natural two-component complex for strengthening and remineralization of enamel RemarsGel. During statistical processing of the obtained data, immediately after sanitation and one month after it, the differences in the indicators of the Ryge criteria in Groups 1 and 2 were statistically insignificant. Twelve months after the sanitation, the Ryge restoration quality indicators in Group 2 were higher than in Group 1 ($P \leq 0.001$). After 36 months, the statistical significance of the difference in the restoration quality indicators increased ($P \leq 0.0001$). These results were confirmed by the data of scanning electron microscopy. Based on the results obtained, stating the state of the quality of the enamel-composite joint, it can be concluded that brushite crystals are highly effective in preventing violations of the integrity of the enamel-composite joint, which has a direct and immediate impact on the quality of restoration.

Conclusion: We consider it necessary to add to the list of main indications for the use of the RemarsGel system one more, a scientifically based indication of the targeted use of the system in the presence of a significant amount of adhesive, both direct and indirect restorations in the oral cavity, especially in the decompensated course of the carious process.(**International Journal of Biomedicine. 2022;12(2):279-283.**)

Key Words: caries • composite material • brushite crystal • individual oral hygiene product • Ryge criteria

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Abbreviations

RC, Ryge criteria; **SEM**, scanning electron microscope.

Introduction

In modern clinical dentistry, the most used method of restoring defects in hard tooth tissues is restoration with composite materials. Moreover, according to a number of domestic and foreign researchers, the indications for the use of composites have expanded significantly in recent years, which is associated with the improvement of their aesthetic and physical and mechanical properties. But despite this, the main problem of composite restoration – violation of the marginal tightness of the enamel-composite connection – remains relevant.[1-8]

Solutions to this problem are developed in two directions: first, the development of innovative techniques for constructing restorations, and second, the modification and development of new restoration materials and adhesive systems with the required physical and chemical characteristics.[2,8-15]

One of the leading causes of depressurization is that the method of preparing the hard tissues of the tooth for adhesive is imperfect – the agent applied to the surface of the enamel is sprayed with air. As a result, under the action of the airflow, the adhesive is displaced to places subject to the lowest air pressure, i.e., on the edges of the cavity, where there is a matrix on one side and tooth tissues on the other. Thus, a "side" is formed at the enamel border, which dissolves with oral fluid over time and, which, in turn, causes depressurization of the enamel-composite joint with subsequent demineralization of the enamel.[1,2,4,5,8,16-19]

In addition, there are a sufficient number of reports in the literature stating that after the preparation and filing of the carious cavity, Ca^{2+} is lost by the tooth enamel, which, according to various sources, occurs from 1 month to 1 year after treatment. To correct these disorders, remineralization therapy is widely used. This problem is especially acute in persons with a decompensated form of activity of the carious process.[4,8,20-23]

The aim of the study was to determine the effectiveness of brushite exposure to correct the marginal permeability of composite restorations in persons with a decompensated form of carious process activity; this study also examined the penetrating ability of brushite in the micro-cracks of the enamel-composite border

Materials and Methods

The basis for obtaining scientific data was a contingent of 120 patients with a decompensated course of the carious process, who underwent complete oral cavity sanitation with the direct composite restoration of 300 teeth. The obtained results were analyzed and interpreted in vivo (the clinical effectiveness of the restoration was assessed according to the Ryge criteria (RC) immediately after treatment and 1, 12, and 36 months after treatment) and in vitro (scanning electron microscopy of the enamel-composite joint after applying the composite and after treatment with the studied means). The material for scanning electron microscope (SEM) was 20 planned extractions of 3 molars of the upper and lower jaws.

The inclusion of patients in the study and further processing of the results obtained was carried out on the basis of voluntary informed consent. The inclusion criteria were the presence of a decompensated form of the carious process (CEE≥16, where C – caries and restored teeth, E – endodontic treated teeth, E – extraction teeth), the absence of removable and conditionally removable orthopedic structures, complete sanitation of the oral cavity, age 18-40 years.

According to the purpose and objectives of the study, two groups of patients were formed: Group 1 (control, n=58): the prevention of recurrent caries after sanitation was carried out using a standard personal hygiene product containing fluorine; Group 2 (experimental, n=62): the prevention of recurrent caries after sanitation was carried out using a natural two-component complex for strengthening and remineralization of enamel RemarsGel.

After sanitation of the oral cavity, all patients were recommended a preventive program of individual oral hygiene, according to group membership. For patients of Group 1, a hygiene product was chosen according to the results of the literature data of marketing analysis of the most used toothpaste. These patients were recommended to use Colgate Total 12 professional cleaning paste two times a day (morning and evening) after learning the technique of brushing their teeth. The participants of Group 2 were recommended to use RemarsGel daily also two times a day (morning and evening).

The prophylactic course of application of RemarsGel consisted of 28 procedures. The criterion for the effectiveness of the course was the absence of damage to the enamel-composite border visible to the naked eye. With visible damage, RemarsGel was used every day until the integrity of the border was restored, and then, according to the prophylactic scheme. RemarsGel prophylactic course was carried out 4 times a year. The rest of the time, all patients used individual oral hygiene products identical to Group 1.

The clinical quality of the restorations was determined using the Ryge criteria immediately after debridement, 1, 12, and 36 months after treatment. This assessment was recommended by the International Organization for Quality Standardization (Protocol PN-EN No. 4049\2003). Scanning electron microscopy was carried out to understand the mechanism of the protective action of brushite. For statistical processing of the obtained results, we used the cluster analysis.

Results and Discussion

The quality of the performed restorations was assessed according to the Ryge criteria for each tooth at various times after the oral cavity was sanitized (Table 1).

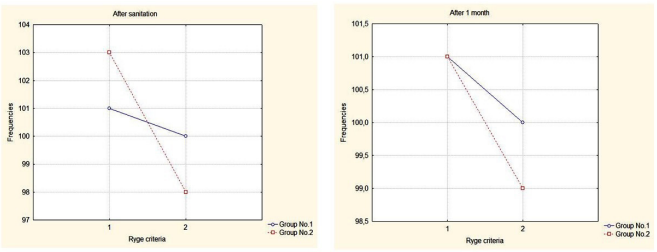
Table 1.

Comparative characteristics of the quality of restorations in the study groups, points.

Timing observations	Group	Ryge score				Total
		0	1	2	3	
Absolute values [n=150] for every group						
After sanitation	Group 1	78	72	–	–	150
	Group 2	77	73	–	–	150
After 1 month	Group 1	77	73	–	–	150
	Group 2	77	73	–	–	150
After 12 months	Group 1	40	83	27	–	150
	Group 2	65	83	2	–	150
After 36 months	Group 1	17	27	91	15	150
	Group 2	41	93	14	2	150
Relative values [n=100%]						
After sanitation	Group 1	52.0%	48.0%	–	–	100%
	Group 2	51.33%	48.67%	–	–	100%
After 1 months	Group 1	51.33%	48.67%	–	–	100%
	Group 2	51.33%	48.67%	–	–	100%
After 12 months	Group 1	26.66%	55.33%	18.01%	–	100%
	Group 2	43.33%	55.33%	1.34%	–	100%
After 36 months	Group 1	11.33%	18.01%	60.66%	10.0%	100%
	Group 2	27.33%	62.0%	9.33%	1.34%	100%

0 points – "ideal" restoration (code 1); 1 point – good restoration (code 2); 2 points – restoration in need of delayed replacement (code 3); 3 points – restoration in need of immediate replacement (code 4).

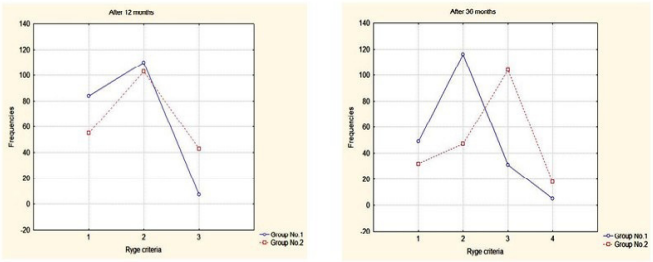
During statistical processing of the obtained data, immediately after sanitation and one month after it, the differences in the indicators of the RC in Groups 1 and 2 were statistically insignificant (P=0.488 and P=0.563, respectively, Fig.1. A-B).



(A) (B)

Fig. 1. *Comparative characteristics of the study population in terms of Ryge indicators immediately after sanitation (A) and 1 month later (B). NewVar0 – Group 1; NewVar1 – Group 2.*

Twelve months after the sanitation (Fig.2A), the Ryge restoration quality indicators in Group 2 were higher than in Group 1 (P≤0.001). After 36 months, the statistical significance of the difference in the restoration quality indicators increased (P≤0.0001) (Fig.2.B).



(A) (B)

Fig. 2. *Comparative characteristics of the study population in terms of Ryge indicators 12 (A) and 36 (B) months after sanitation. NewVar0 - Group 1; NewVar1 - Group 2.*

The results of cluster analysis are shown in Figure 3. In cluster analysis, the K-means method was used with a sequential increase in the number of clusters from two to 5 and the number of iterations from 10 to 20. The choice of the final number of clusters was determined based on the situation when a large number of clusters only detailed the obtained clinical results (RC) without highlighting new features of the identified dynamics of the process.

The mean value of the variable in Cluster 1 (Group 2) was noticeably lower than in Clusters 2 and 3 (Group 1), and the range of dispersion of the mean values of the variable in the groups of patients was not significant (P<0.1) and does not affect objectively estimated parameters. Such a difference in the average values of the variable can be associated with the quality of the enamel-composite joint according to the RC (visual control) since immediately after treatment, the mean values of the variable in different groups differed slightly; in this variation series not only the mean values of the variables in different groups of patients changed, but also these values differed significantly from each other. In addition, Cluster 2 (95 cases) was identified, in which initially high values of variables at 36 months after treatment corresponded to those of Cluster 1. The results of statistical processing clearly confirm the previously obtained clinical results of the Ryge parameters.

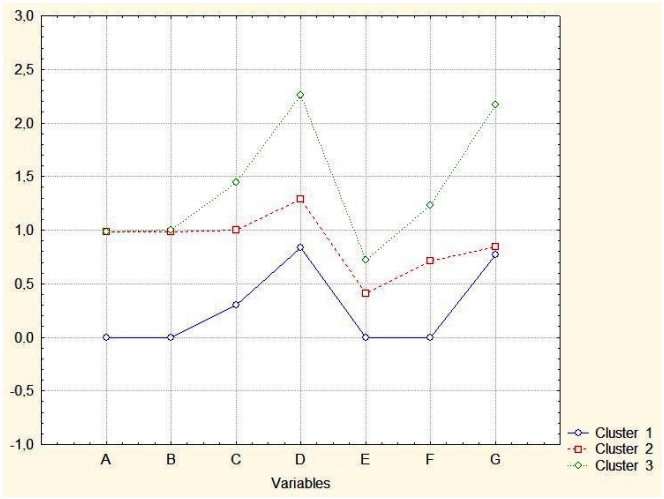


Fig. 3. *Cluster analysis*

Variable A – RC after sanitation; Variable B – RC (visual control), 1 month after sanitation; Variable C – RC (visual control), 12 months after sanitation; Variable D – RC (visual control), 36 months after sanitation; Variable E – RC (instrumental control), 1 month after sanitation; Variable F – RC (instrumental control), 12 months after sanitation; Variable G – RC (instrumental control), 36 months after sanitation.

In the SEM study of samples obtained in Group 1 and Group 2 immediately after sanitation, where the restoration was carried out using an identical adhesive system and composite, there were no visual differences in the quality of the state of the enamel-composite joint (Figures 4, 5).

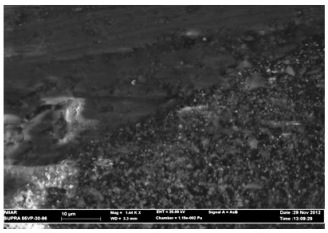


Fig. 4. *SEM of an enamel-composite joint immediately after treatment (Group 1).*

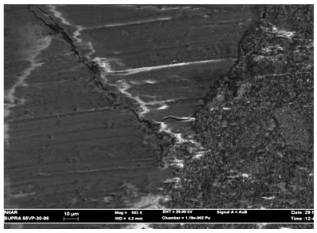


Fig. 5. *SEM of an enamel-composite joint immediately after treatment (Group 2).*

After the sample was treated with a hygienic agent in Group 1, when scanning in the area of the enamel-composite joint, we noted the ability of the hygienic agent to be adsorbed on its surface, especially in areas with a pronounced prismatic enamel microstructure (with an increase in x1500, an insignificant number of particles of a hygienic agent of a non-crystalline structure was noted, Fig. 6).

After processing the sample in Group 2 with the RemarsGel system and scanning in the area of the enamel-composite joint, we noted the presence of a continuous film of brushite crystals covering the entire field of study, including

the enamel-composite joint itself. The photograph shows the adhesive nature of the fastening of brushite crystals (the crystals did not collapse, and their connection with the enamel was not disturbed, even during the intermediate processing of the sample). This pattern was observed both along the entire perimeter of the enamel-composite joint, and over the entire surface of the enamel of the test sample, regardless of the microstructure (Fig.7).

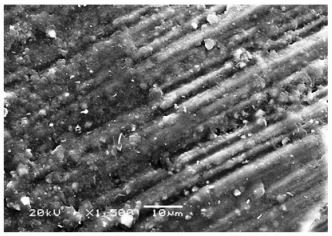


Fig. 6. *SEM of an enamel-composite joint after treatment with Colgate Total 12 (Group 1).*

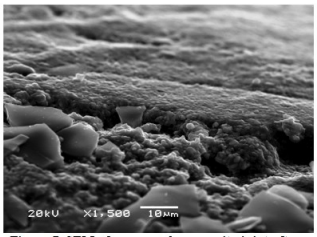


Fig. 7. *SEM of an enamel-composite joint after treatment with RemarsGel (Group 2).*

In the course of the study, using laboratory research methods, it was established that the unique physical and chemical properties of brushite crystals (adhesiveness, high adaptability, and strength) provide the RemarsGel system with a number of unique properties that determine its advantage in maintaining the tightness of the enamel-composite enamel connection, compared to Group 1, and, consequently, increasing the durability of the consistency of the restoration.

Thus, the above problems determine the relevance of permanent protection of the enamel-composite border, including the use of personal hygiene products, which, in addition to maintaining the required level of oral hygiene, would have pronounced remineralizing properties. In particular, this applies to brushite crystals. Brushite has unique adhesive properties and an affinity for enamel surface hydroxyapatite crystals. [9,17,24-30]

The system consists of two components (Tube 1 and Tube 2) which are used strictly alternately without mixing. According to the developers, the compounds that make up the RemarsGel have the ability to gradually penetrate into the enamel of the teeth and replace the lost calcium. RemarsGel actually "repairs" the area of tooth enamel that has lost its strength, strengthens it, and helps restore the natural protection of the tooth.[1,2,5,6,8,31]

From a scientific point of view, the principal mechanism of the system's action is a chemical reaction that occurs during the sequential use of reagents in the oral cavity (calcium nitrate from Tube 1 is mixed with ammonium hydro phosphate from Tube 2). As a result of this reaction, which is safe for humans, a brushite crystal is formed on the surface of the enamel, similar in composition to the main structural substance of tooth enamel, the hydroxyapatite crystal. Due to its small size (40-50 nm), the brushite crystal penetrates deeply into the tissues of the tooth, restores enamel damaged by caries, closes micro-cracks, and quickly relieves tooth sensitivity (even after professional whitening).[3,5,9,10,32-35]

Currently, there are reports that a brushite crystal acting directly on the focus of demineralization not only densifies it, that is, replaces a structural defect, but also forms new mineral compounds, i.e. exhibits chemical activity. In terms of abrasiveness, the complete absence of the aggressive effect of the complex has been demonstrated, which makes it possible to prevent enamel abrasion during cleaning and to effectively use the drug with increased tooth sensitivity.[1,2,9]

Conclusion

Based on the results obtained, showing the state of the quality of the enamel-composite joint, it can be concluded that brushite crystals are highly effective in preventing violations of the integrity of the enamel-composite joint, which has a direct and immediate impact on the quality of restoration. We consider it necessary to add one more to the list of main indications for the use of the RemarsGel system: a scientifically based indication of the targeted use of the system in the presence of a significant amount of adhesive, for both direct and indirect restorations in the oral cavity, especially in the decompensated course of the carious process.

Competing Interests

The authors declare that they have no competing interests.

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