Objectives for a new concept of personalized treatment and prevention of recurrent caries based on modification of dental filling materials

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Abstract. Current dentistry has achieved pronounced success in highly effective diagnosis, prevention, and treatment of dental caries; however, caries incidence rate remains high.
In this regard, there is a need in the study of composition and properties of dental materials, as well as the principles of changing and improving their physical, mechanical, and chemical parameters. According to the purpose and objectives of the study, we studied the physical and mechanical properties of the polymer filling materials at electromagnetic field exposure.

As a result of the strength tests carried out to determine the physical and mechanical properties of the materials, the data was obtained for a reliable increase in strength of materials and maximum load required for destruction of the sample in compression, diametrical fracture, and bending after electromagnetic field exposure on filling materials.

Thus, at electromagnetic field exposure on filling materials, an increase in strength parameters in all the studied materials was noted, which predicts an increase in the service life of fillings and improves the quality of filling and treatment in general, and will also contribute to prevention of recurrent caries by reducing the number of complications associated with chipped and cracked fillings during chewing load.

Keywords: preventive and personalised dentistry; dental caries; polymer filling materials; electromagnetic exposure; strength properties; innovative technologies; prognosis; tailored treatment.

Background

Current dentistry has achieved pronounced success in highly effective diagnosis, prevention, and treatment of dental caries; however, caries incidence rate remains high. Therefore it is necessary to search for new approaches to a comprehensive study and solution of the dental caries problem in the field of preclinical diagnosis, tailored prevention and treatment. A large number of filling materials and methods of its application do not provide highly effective prevention and treatment of dental caries because of complications such as secondary and recurrent caries, there is a necessity for their improvement and development of new aspects of their production and use. In this regard, there is a

need in the study of composition and properties of dental materials, as well as the principles of changing and improving their physical, mechanical, and chemical parameters [1-3].

Successful outcome of caries treatment depends on many factors, including service life of fillings; therefore, the quality of dental materials is the key problem of predictive, preventive and personalized dentistry. An important characteristic of filling materials is strength - the ability of the filling to withstand mechanical stress, without being destroyed. Strength depends on the structure of the material, molecular and atomic cohesion. Thus, it is necessary to search for options of modification of polymer fillings by physical fields, which will allow to increase resistance and micro hardness of the material, so that it becomes more resistant to mechanical and physical influences, which will contribute to a longer service life of fillings and prevention of secondary caries [1, 3].

The carried out complex studies have indicated strengthening of macromolecular cohesion of adhesive compounds during activation of polymer macromolecules by physical fields. The authors have proven that magnetic field exposure applied to polymer resins increases hardness and strength of the samples due to ordering of the long-range structure, which indicates the material mechanical properties improvement. Based on this data, it is possible to predict higher increasing strength parameters of polymer-based filling materials after physical field exposure. In connection with the mentioned above, it is advisable to study the electromagnetic field for the strength properties of polymer filling materials to increase their resistance parameters and recurrent caries prevention [1-3].

Materials and methods

According to the purpose and objectives of the study, we studied the physical and mechanical properties of the polymer filling materials at electromagnetic field exposure at the Dental clinic base. Hybrid and macro - filled materials were selected for the study. For the in vitro study, we used Dentlite (Vladmiva, RF) and Solitaure (Heraeus Kulzer, Germany) composite filling materials (Table 1).

Table 1. The distribution of polymer filling materials before and after electromagnetic field exposure

Group	Filling material	The number of samples
A group EMF +	Solitaire	10 (25%)
	Dentlite	10 (25%)
B group EMF -	Solitaire	10 (25%)
	Dentlite	10 (25%)
Total	40 (100%)	

In accordance with Table 1, it follows that the samples of the polymer filling materials of two groups were equally distributed. The sample preparation technique: each sample of the study group was preliminarily placed in the system for polymer materials in constant electromagnetic field

conditions with strengths of $22x10^4$ A/m for 25 minutes. Then the material samples of the both groups were cured by polymerization light [1, 3].

To determine the physical and mechanical properties of the Dentlite and Solitaure filling materials after electromagnetic field exposure, strength tests were carried out in accordance with the National Standard N31574-2012, including determination of the strength parameter at diametric break and bending. For objective assessment of the physical and mechanical properties of the filling materials, we also conducted tests to determine the compressive strength. The prepared samples were kept in a thermostat for a day before testing. Strength tests were carried out on an IR 5040-1 testing machine.

Results

As a result of the strength tests carried out to determine the physical and mechanical properties of the materials, the data was obtained for a reliable increase in strength of materials and maximum load required for destruction of the sample in compression, diametrical fracture, and bending after electromagnetic field exposure on filling materials (Table 2).

Table 2. Strength parameters of polymer filling materials before and after electromagnetic field exposure

Filling materials	Dentlite		Solitaire	
Strength (N)	Control group	Study group	Control group	Study group
Mean (min/max)				
Compression	3913.6 (3814.4/4028.8)	4110.7 (3910.1/4408.5)	3304.8 (3298.0/3311.0)	3346.6 (3321.9/3399.1)
Diametrical fracture	1089.1 (1001.7/1185.6)	1315.7 (1250.1/1437.8)	1095.3 (1012.1/1191.4)	1247.3 (1105.1/1388.1)
Bending	24.1 (19.5/28.7)	28.7 (21.8/34.0)	20.6 (18.9/22.1)	24.3 (22.5/26.2)

Abbreviations: Mann-Whithey U test p-level $p< 0.5$

Table 2 presents a comparative characteristic of the average values of compressive strength parameters of the Dentlite and Solitaire filling materials with and without electromagnetic field exposure. A statistically significant difference in the results was obtained, confirmed by the received results of the average values. Similar results were obtained in the study of other strength parameters.

According to the statistical analysis of the strength parameters of the Dentlite material under compression, it follows that, in the control group without electromagnetic field exposure, the average

value of the load applied to the sample for its destruction was 3913.6 (3814.4 / 4028.8), and in the study group was 4110.7 (3910.1 / 4408.5), which indicates an increase in strength characteristics.

When testing the diametral fracture of the Dentlite material, the same tendency of increase in the strength properties of the material was observed: in the control group without electromagnetic field exposure, the average value of the load applied to the sample was 1089.1 (1001.7 / 1185.6), and in the study group, was 1315.7 (1250.1 / 1437.8).

During the bending test of the Dentlite material, there was also an increase in the strength properties of the material: in the control group without exposure to the electromagnetic field, the average value of the load applied to the sample was 24.1 (19.5 / 28.7), and in the study group, was 28.7 (21.8 / 34.0), which indicates an increase in the strength of the material.

In the Solitaire filling material, the same tendency of increasing compressive strength was observed from 3304.8 (3298.0 / 3311.0) in the control group to 3346.6 (3321.9 / 3399.1) in the study group; in bending from 20.6 (18.9 / 22.1) in the control group to 24.3 (22.5 / 26.2) in the study group. Thus, the differences between the control and the study group are statistically significant.

Conclusion

Considering that in the oral cavity, the chewing load is distributed in various directions, including tangentially, which, for example, predicts bending and diametral rupture tests, these studies made it possible to reliably evaluate the biomechanics of all types of injuries. As a result of the strength tests for compression of Dentlite and Solitaure filling materials after electromagnetic field exposure, an increase in strength of the materials of the research groups was achieved. The analysis of comparative characteristics revealed the most pronounced increase in strength parameters in the Dentlite material, which is due to the better susceptibility of its microstructure to these types of strength tests.

Thus, at electromagnetic field exposure on filling materials, an increase in strength parameters in all the studied materials was noted, which predicts an increase in the service life of fillings and improves the quality of filling and treatment in general, and will also contribute to prevention of recurrent caries by reducing the number of complications associated with chipped and cracked fillings during chewing load, which fits into the concept of preventive and personalised medicine.

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