A Subsidiary Physical Research of Glass Ionomers

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In Pediatric practical dentistry, beside the great variety of direct dental restoration materials the dentist must take into account several factors such as morpho-structural particularities of temporary teeth, the clinical situation, physician performance, behavioural features of children and last but not least the quality of the chosen material. Thus, we investigated the behavior of glass ionomers cements in occlusal stress by determining their mechanical properties. The study aims to determine the vertical compressive strength values, which is one of the mechanical properties of filling materials, the strength of materials being useful in the research of occlusal forces exerted on the future restorations. We had used two glass ionomer cements and a resin modified glass ionomer cement, which then we have tested them to obtain comparative data of the resistance for vertical compression.

Keywords: *glass ionomers cements, mechanical properties, vertical compression, temporary teeth*

Dental caries (decay) is one of the most prevalent chronic children diseases, seven times than hay fever and five times more common than asthma [1, 2]. The etiological factors are extremely different and have a large area of action. The most common carries risk factors are: biological, behavioural, environmental, and lifestyle-related factors [2, 3].

O lot of Romanian researchers who had preoccupations in the field of dentistry studied the proprieties of different types of restorative materials. They are continuously involved in developing the knowledge concerning applications of different types of such materials [4-6].

Restoring carious teeth is one of the major treatment needs of young children. A restoration in the primary dentition is different from a restoration in the permanent dentition due to the limited lifespan of the teeth and the lower biting forces of children [7, 8]. Choosing direct coronary restoration materials must take into consideration several factors: particularities of the removal process of the caries in temporary teeth, leading to obtain shutter cavities, which cannot always take into account the rules of Black. From this point of view the filling material must be the one to make a link between tooth and filling [9, 10].

This leads us to use direct coronary restoration materials such as glass ionomer cements (GIC) or resin modified glass ionomer cements. It is well known that chemical structure and molecular organization of glass ionomer causes certain behaviours after inserting fillings in the oral cavity [6]. They are a useful choice and used in the daily routine for restorative therapy concerning fillings which are not situated in high-stress sites or in temporary teeth. However compared to permanent filling materials like resin-based composites, when we have to restore a temporary tooth, GIC show several advantages, such as the ability to adhere to moist enamel and dentin without any intermediate agent, which can increase working time and is important in the case of a stirred child. Other advantages are the anti-cariogenic properties such as the long-term fluoride release, biocompatibility and low coefficient of thermal expansion which support their valuable position in the daily dental practice [11-15].

Resin modified glass ionomer cements and compomers should be considered for restorations in primary teeth because of their biocompatibility, antibacterial properties, ability to leach fluorides, and because of their better physical properties [16].

Due to the characteristics of children's morpho-structural features of the primary teeth and young permanent teeth and especially the period of time that a temporary tooth has on the dental arch we can focus on glass ionomer cements [9, 10].

Glass ionomer cements are inexpensive compared with resin composites and less demanding with respect to the clinical application. By increasing the powder D liquid ratio, the high viscous or condensable GICs, with better mechanical properties than traditional GICs were developed for atraumatic restorative treatment [17].

Incomplete removal of caries has been advocated in techniques such as indirect pulp capping and alternative restorative treatment (ART). In these procedures, glass-ionomer cements are used, in direct contact with residual carious tissue, to reduce the viability of residual bacteria, thus preventing the occurrence of secondary caries [18, 19].

The fluoride release from glass ionomer cements is characterized by an initial rapid release, followed by a rapid reduction in the rate of release of fluoride after short time [20-22]. Besides antibacterial activity, such materials should also have good biocompatibility with the dentin-pulp complex [23, 24].

Glass ionomers cannot stand for long periods of time the occlusal stress. They still can be used as restoration material for direct coronary fillings for the temporary teeth that will be lost in a short period of time from the dental arch. In case of coronary restoration of temporary teeth, which must be left on the dental arches for a long period of

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time, it can be considered using direct restoration materials that resists to the occlusal stress and can meet the requirements demanded by masticatory function or aesthetics. Of course, we should take into consideration children's behavioural particularities this being a factor which is taken into account. Therefore, to a child where there are not fulfill the requirements to achieve a composite restoration, there will be made a coronal restoration with glass ionomer or resin modified glass ionomer cement until it can be achieved the above mentioned [9, 10].

Recent investigations have led to improved physical properties of glass ionomer cements, some of them being with high resistance. Glass ionomer cements resistance under masticatory forces can be shown by several types of tests on which we stopped and focused on the vertical compressive strength test, which is relevant in terms of tensions created within them, under masticatory forces.

The determination of vertical compressive strength values is important in choosing materials for crown restoration, in first and second Black class cavities, supervising the additional information regarding the choice of the direct coronary restoration material in the practice of pediatric dentistry.

Experimental part

Materials and methods

In this study we considered the class of direct coronary restorative of glass ionomer cements and resin modified glass ionomer cements. After a random choice we have selected two materials such as Ketac Molar Easymix (KM) and Fuji IX (F IX) from the class of glass ionomer cements and Vitremer (V) which is resin modified glass ionomer cement.

In order to perform the testing of the vertical strength of the selected glass ionomer cements we went through several stages. Stages of researching the vertical compressive strength are:

- the implementation of models afterwards used as patterns;
- achieving the actual patterns;
- the implementation of specimens to be tested;
- the actual testing of specimens;
- tuition, registration and evaluation of results.

We have made five specimens of each material by realizing a total of 15 specimens. Specimens were made to have a diameter of 3 mm and a height of 6 mm (fig. 1).

In the first stage of the development of models by which patterns will be manufactured, test pieces were made of wax models. Taking into account the fact that wax models can be deformed easily and they request certain temperatures or pressure, we finally realized them of self-curing acrylic models (fig. 2) by wrapping wax models and then by condensing the acrylate in the obtained patterns.

Models were finished with the mills, so that we get the cylinder diameter of 3 mm and the 6 mm in height.

Research patterns were created by impression of the models made by self-curing acrylic, resulting a cylinder with an internal diameter (denoted by Φ) of 3 mm and a height (denoted by h) of 6 mm (fig. 3).

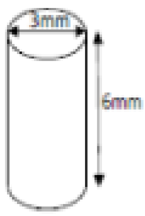

Fig. 1. The sketch of the future specimen

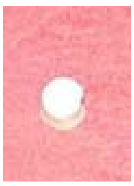

Fig. 2. The model made from self-curing acrylic material

Fig. 3. The imprint of the models

Fig. 4. Preparing the imprint and the glass ionomer cement

Making the specimens was performed by injecting the pattern described above, with the two glass ionomer cements and the resin modified glass ionomer cement chosen randomly. From each type of material five specimens were made, obtaining 15 specimens to be subject to further testing.

For making glass ionomer cement specimens we have done as follows: we had mixed the liquid with the powder on to the waxed paper, in proportions recommended by the manufacturer, and in accordance with the instructions provided.

Taking into account that this type of crown restoration materials is sticky, the pattern was isolated with vaseline for medical use. After isolation, it is put on a flat surface. To avoid flaws that could affect the structure of the specimen or the air bubbles inside it, the pattern was placed on a vibrating table.

Once completely filled, it was covered with a glass plate, on which it was applied a slight pressure to remove excess.

Ionomer cement hardening was expected (fig. 5). The difference in making the specimens from the resin modified glass ionomer cement was that at the end we did not expect the hardening but we cured the material with the light curing lamp for 40 s on each side of the impression. We have done the curing of the specimens from both sides, because the future specimen has a height of 6 mm and the UV light from the lamp cannot penetrate so deep to ensure complete setting of the material in depth, only from one side.

After setting the material, specimens were finished with the cutters and then stored in distilled water for 24 h. In the first phase we carried out five specimens of Ketac Molar Easymix (fig. 6), afterwards we proceeded to achieve

Fig. 5. Expecting the hardening of the glass ionomer cement

Fig. 6. The pattern of Ketac Molar Easymix

Fig.7. The pattern of Fuji IX

Fig. 8. The pattern of Vitremer

specimens of Fuji IX (fig. 7) and finally the ones from Vitremer (fig. 8).

After making the test specimens from the chosen material, we followed the actual testing phase, to obtain vertical compressive strength values. To achieve vertical compressive strength values all specimens taken were tested.

Tests were made with universal testing device Zwick Roell Z005, using special devices for this type of testing.

We had applied the forces on the test specimen. Forces were applied perpendicular to the opposite ends of the specimens, a cylinder, with diameter of 3 mm and 6 mm height (fig. 9).

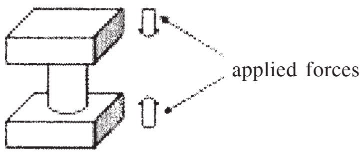

Fig. 9. Outlines the applied forces

Fig. 10. Test-piece tested on Zwick - Roell Z005 universal testing machine

In the universal testing device Zwick Roell Z005, were mounted two special devices as two parallel plates. Located at the base plate, there were drawn signs that marked the middle of the plate. Specimens were located in the middle of the base (fig.10).

Each specimen was measured and tested individually for each type of material and findings were recorded. In total there were 15 tests for vertical compression.

Height (denoted by h) and diameter (denoted Φ) of 15 specimens were measured individually before testing.

Specimens were tested to fulfill the vertical compressive strength. They were placed between two metal plates in the machine Zwick - Roell Z005. The vertical force was applied to the specimens and this force was at a speed of 1mm/minute until the fracture occurred and the amount of force was recorded by the device.

The value of the applied force was recorded by a universal testing device Zwick Roell Z005 as graphs, and tables were recorded with numeric values of the forces.

These data were processed and converted into MPa (megapascal) using the formulae:

$$A = \frac{\Phi^2 x 3.14}{4} \qquad CV = \frac{F}{A}$$

The meaning of formula for calculating the vertical compressive strength values is: CV is vertical compressive strength expressed in MPa, F is the force at which fracture occurred, Φ is the specimen diameter and h is the height of the specimen.

Results and discussions

The findings of the height (denoted by h) and the diameter (denoted Φ) of those 15 specimens individually measured before testing are shown in the next table (fig. 11):

		E1	E2	E3	E4	E5
KM	h	6	6	5.9	5.8	5.9
	Φ	2.9	2.9	3	3.1	3
FIX	h	6	5.9	6	5.9	6
	Φ	2.9	3	2.9	3	3.1
V	h	6.1	6	5.9	6	5.8
	Φ	3	3	2.9	2.9	3.1

Fig. 11. Dimensions of the specimens

The values of the applied vertical forces needed for the fracture process of specimens are presented in the following table (fig. 12):

		E1	E2	E3	E4	E5
KM	F	288	278	290	286	288
FIX	F	534	530	529	534	530
V	F	669	670	659	655	665

Fig. 12. Force that occurred when the specimen fracture

All data presented in the above tables have been introduced in the formula for calculating the vertical compressive strength values. After the calculation, the obtained data were entered in the table below (fig. 13):

		E1	E2	E3	E4	E5
KM	CV	43.63	42.12	41.07	37.93	40.79
FIX	CV	80.90	75.07	80.15	75.63	70.29
V	CV	94.75	94.90	99.84	99.24	88.19

Fig. 13. Table with vertical compressive strength

In statistical terms, in the table below (fig.14) we introduced the average value for each type of material. Vertical compressive strength values are expressed in MPa.

In order to easily analyze the results for these types of materials, we used graphical representation (fig. 15)

The lowest value of vertical compressive strength is glass ionomer cement Ketac Molar and the highest value of vertical compressive strength is direct crown restoration material, Vitremer, resin modified glass ionomer cement.

The vertical compressive strength is an important property of restorative materials, particularly in the process of mastication and this test is more suitable to compare

Classification of restorative material	The name of restorative material	The value of vertical compresive strength in MPa
glass ionomer cement	Ketac molar	41 MPa
glass ionomer cement	Fuji IX	76 Mpa
resin modified glass ionomer cement	Vitremer	95 Mpa

Fig. 14. Table with the average value of vertical compressive strength values

brittle materials, which show a relatively low result when subject to tension [25].

In addition to information provided by the manufacturer, and clinical indications of these materials we bring additional information regarding the choice of direct coronary restoration material in pediatric practice in certain given clinical situations. The selection of dental restoration material, in first and second class Black cavities, at the temporary teeth, where chewing forces are high, it can be done according to the time which they have on the dental arches. So, a temporary tooth that has a shorter period of time in the mouth can be successfully reconstructed with the Ketac Molar, while Vitremer can be used for temporary teeth that remain for longer periods of time on dental arch. Fuji IX has a mean value of the vertical compressive strength and its use in restoring the tooth should depend of the remaining period of time on the dental arch.

In a study, the authors have shown, after testing, that Fuji IX has higher strength values than Ketac Molar [26].

Although glass ionomer cements can withstand occlusal stress for a period of time, vertical compressive strength values provided by this study suggests the possibility of using these materials in temporary teeth with cavities of class I and II Black at children aged between 8 and 10 years, or in those cases where it cannot be placed another restoration material because of their application conditions that cannot be fulfilled due to various reasons (for example children's behavioural particularities). However, the two glass ionomer cements tested do not have a very high vertical compressive strength, so that for the temporary teeth that remain for a longer period of time on the dental arcade, we should make another choice.

In another study regarding the evaluation of adhesive and compressive strength of glass ionomer cements, published in 2011, the authors compared the compressive strength of different classes and brands of glass ionomer cements and also evaluated their capacity of adhesive bond strength to ceramo-metal alloy. In their study they referred to GC Fuji II (GC Corporation, Tokyo), Chem Flex (Dentsply DeTrey, Germany), Glass ionomer FX (Shofu-11, Japan), MR dental (MR dental suppliers Pvt Ltd, England), Ceramo-metal alloy (Ni–Cr: Wiron 99; Bego, Bremen, Germany) and reached the conclusion that the comparative compressive strength of MR dental glass ionomer cement was maximum, followed by Chemflex, then GC Fuji and minimum with GI FX [27].

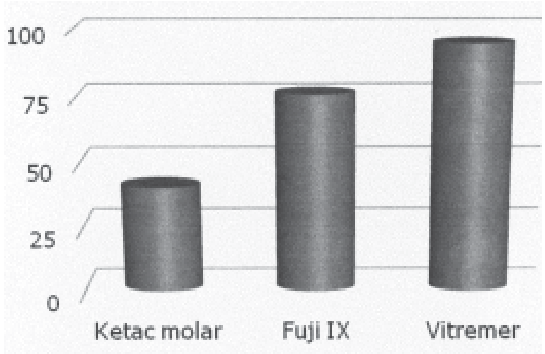

Fig. 15. The values in Mpa of vertical compressive strength

Our study compared two glass ionomer cements and one resin modified and shows that resin modified glass ionomer cements have a much higher value than glass ionomer cements.

The resin modified glass ionomer cement Vitremer has the highest value of compressive strength and this indicates that it can be used in all deciduous teeth. However, composite restorative materials probably have a higher vertical compressive strength as it was shown in a study, where, after testing of six composites, the authors obtained values of compressive strength over 200 MPa [28].

Also in another study, the authors revealed values of compressive strength of dental composites photo-activated with different light tips, over 290 MPa [29].

Further tests should be undertaken to compare and evaluate the other strength characteristics like flexural strength, bond strength, and properties like hardness, setting, and working times of the experimental cement [30].

Our study assessed, compared and evaluated glass ionomer cements and resin modified glass ionomer cements, but the testing should be done for more brands of glass ionomer cements and also in comparation with other classes of restorative materials such as composite.

Conclusions

Glass ionomer cements have vertical compressive strength values much lower than the resin modified glass ionomer cements. Of the two glass ionomer cements, Fuji IX has a vertical compressive strength value almost two times higher than Ketac Molar. In our study Vitremer which is resin modified glass ionomer cements has the highest value of the vertical compressive strength.

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