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Evaluation of surface roughness of four restorative materials, used for restorations in primary dentition

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Abstract

Aim: *The aim of this study is to evaluate the surface roughness values of four restorative materials, used for restorations in primary dentition.* ***Materials and methods:*** *Five disc-shaped specimens were prepared for each material using a cylindrical Teflon mold with dimensions 5x2 mm, covered with Mylar strips. After setting, the specimens were polished sequentially with coarse, medium and fine aluminum oxide discs. The mean surface roughness of all the samples after polishing was measured using a surface profilometer.* ***Results:*** *Fuji IX GP showed statistically significant higher surface roughness values. There was no statistically significant difference in roughness values between the other three materials, although the giomer Beautifil II demonstrated the lowest roughness values.* ***Conclusions****: It can be concluded that the composition (presence and absence of resin) and particle size of the restorative materials affect their surface characteristics and their degree of polish ability as the material with larger particles size and without resin content, Fuji IX GP, demonstrated significantly higher surface roughness values.*

Keywords: primary dentition, surface roughness, restorations

Introduction

The main purpose of restorative therapy in primary teeth is elimination of discomfort and pain, restoration of their anatomical shape and function and their maintenance until the time of physiological exfoliation [1,2,3]. Placing a restoration, however does not guarantee control of carious disease. In case the etiological factors are not controlled, the restorations would have a limited capacity to survive. That is why the restorations in primary dentition usually do not last long and the main reason for their failure is development of secondary carious lesion [4,5,6].

Secondary caries lesion is defined as a primary lesion, developing near an existing restoration, used for a certain period of time [6,7]. Prevention of secondary caries lesions includes control of the main etiological factors related to their appearance. It is concluded, as a result of many scientific studies, that the presence of dental biofilm is the etiological factor that has greatest importance in the development of such lesions [8,9]. Plaque accumulation on restoration surface is affected by many factors, some of which are presence of fluorides in oral environment, release of fluoride from the restorative material, hydrophobicity of the restorative material, saliva flow, poor oral hygiene, and last but not least, the surface roughness of the restorative material [10,11,12].

As a result of many scientific studies, it is established that the development of a secondary caries lesion strongly depends on the surface characteristics and particularly on the surface roughness of the restorative material. Rough surfaces facilitate the accumulation of dental biofilm by promoting retention, survival and reproduction of the microorganisms related to the development of caries lesions - Str. Mutans[13]. Being attached to such a surface, microorganisms are protected against shear forces and consequently have enough time to establish a strong and irreversible attachment to the surface of the enamel or the restorative material [14]. All this may lead to excessive accumulation of dental biofilm and thus gingival inflammation, deterioration of optical properties of the material and, in the long term, periodontal disease and secondary caries lesion. By contrast, achieving a smooth restoration surface decreases plaque accumulation and surface staining, provides patients comfort and sufficient optical properties [15,16,17]. It becomes clear that maintaining a smooth surface may facilitate the prevention of caries and periodontal disease. That is why achieving a smooth, non-retentive surface of restorations is among the ultimate goals of the restorative procedures [15,18,19]. There are many instruments used routinely for polishing of restorations but the basic ones are diamond and carbide burs, abrasive discs smeared with aluminum oxide, strips and rubber cups [20,21,22].

Aim

The great frequency of secondary caries lesions development in primary dentition and its dependence on the surface roughness of restorative materials used defined the purpose of the present study - evaluation of surface roughness of some restorative materials, used for restorations in primary dentition.

Materials and methods

Four restorative materials were tested in this study: Glass-ionomer cement (Fuji IX GP extra), nanofilled light-cured composite (Estelite Sigma Quick), compomer (Dyract XP) and giomer (Beautifil II). Information such as material type, manufacturer and size of particles is listed in Table 1. Five disc-shaped specimens were prepared for each material using a cylindrical Teflon mold with dimensions 5x2 mm, covered with Mylar strips.

Materials for each sample were prepared according to the manufacturer’s instructions and inserted into the molds slightly excessively. The material surfaces in the molds were covered with Mylar strips on both sides and pressed between two glass slides until the extruded excess material was removed.

Table 1- Restorative materials used in this study and their characteristics.

Material	Number of specimens	Type	Manufacturer	Mean size of particles
Fuji IX GP	5	Conventional glass-ionomer cement	GC Corporation,Japan	10 µm
Estelite Sigma Quick	5	Nanofilled composite resin	Tokuyama Dental, Japan	0.2 µm
Dyract XP	5	Compomer	Dentsply, USA	0.8 µm
Beautifil II	5	Giomer	Shofu, USA	0.8 µm

The conventional glass-ionomer cement was allowed to set at room temperature for 15 minutes. The nano-filled composite resin, compomer and giomer were polymerized through the glass slide using a LED wireless curing unit COXO DB-686 Latte CE. After setting, the specimens were cleaned and each of them was polished sequentially with coarse, medium, and fine aluminum oxide discs (Soft-Lex discs -3M ESPE, St Paul, MN, USA). A new disc was used for each third specimen.

The surface roughness measurement of all tested materials was obtained using a surface profilometer ("Surtronic 3+", Taylor Hobson, UK), fig. 1. The radius of the tracing diamond tip was 5 µm.

Figure 1 - Profilometer "Surtronic 3+" , Taylor Hobson, UK

The surface roughness of each specimen was measured in 5 different positions immediately after polishing with aluminum oxide discs (Soft-Lex discs -3M ESPE, St Paul, MN, USA). The average roughness value (Ra, µm) of each disc was the mean of the Ra values measured in 5 different positions.

To conduct this test, the following conditions were fulfilled:

- The measuring speed was 1 mm/s
- The sampling length (Lr) was 0,25 mm
- Evaluation length (Ln) was 1.25 mm
- Traversing length (Lt) was 1.50 mm
- The accuracy of the measured value Ra was 0,02 µm

Results

The results obtained from the surface roughness measurements of the four tested materials are shown in Fig. 2. The mean value of the surface roughness for each material was calculated and the results are presented in Table 2. The highest mean surface roughness value was obtained from Fuji IX GP, followed by Estelite Sigma Quick, Dyract and Beautifil II.

Table 2 – Descriptive statistics of surface roughness values Ra. 102 [µm] of the tested restorative materials.

RA	N	Mean	Std. deviation	Std. error	95% confidence interval for mean		Minimum	Maximum
					LB	UB		
BEAUTIFIL II	15	40,27	12,26	3,16	33,48	47,05	16	60
FUJI IX GP	16	91,25	19,14	4,78	81,05	101,45	60	120
ESQ	12	54,75	25,03	7,22	38,85	70,65	22	98
DYRACT	18	47,78	13,74	3,24	40,95	54,61	28	78
Total	61	58,70	26,48	3,39	51,92	65,49	16	120

One-way analysis of variance (ANOVA) test was used to compare the difference between the surface roughness`s mean values among the studied materials. The variations between the groups were analyzed and the results are presented in Table 3. The mean Ra value for Fuji IX GP was statistically significantly higher than the Ra values of Dyract, Estelite Sigma Quick and Beautifil II (Tab. 3, $p<0.05$). There was no statistically significant difference in mean roughness values between Dyract, Estelite Sigma Quick and Beautifil II (Tab.3, $p>0.05$). Beautifil II demonstrated the lowest mean roughness values of all tested materials, but without a statistically significant difference, except for Fuji IX GP (Tab. 3).

Table 3 - Analysis of the influence of the type of material on the surface roughness of the tested samples.

p values *	Beautifil II	Fuji IX GP	ESQ	Dyract XP
Beautifil II		0,0000	0,4169	0,4937
Fuji IX GP	0,0000		0,0026	0,0000
ESQ	0,4169	0,0026		0,9495
Dyract XP	0,4937	0,0000	0,9495	

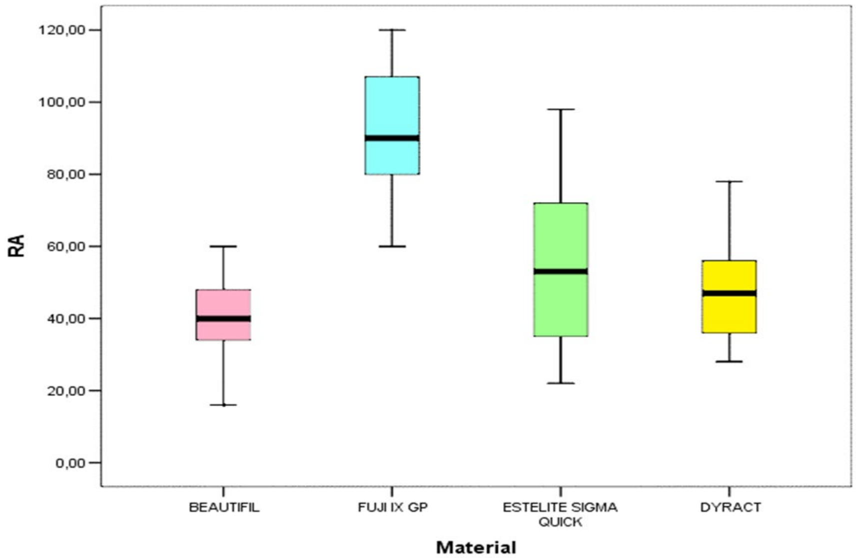

Figure 2- Box-plot graph of measured surface roughness values (Ra. 102 [μm]) of the tested restorative materials.

Discussion

There are several main classes of restorative materials for restorations in the primary dentition. However, in recent decades, aesthetic ones have been preferred - glass-ionomer cements, composite resins, compomers and giomers. Each of the mentioned materials has its advantages and disadvantages and is suitable for use in different situations. There is still lack of evidence of the best restorative material for restorations in primary dentition.

Techniques, applied routinely for finishing and polishing of restorations include usage of diamond and carbide burs, strips, rubber cups and abrasive discs, smeared with aluminum oxide [20,21,22]. Some authors claim that the use of aluminum polishing discs results in a smoother surface, and the explanation is rooted in the uniform abrasion of the matrix and filler particles [20,21,22]. That is why the polishing of the samples in our study involves processing with such discs - from fine to coarse.

The materials subject to this study have different compositions - a conventional glass-ionomer cement, composite resin, compomer and giomer. As a result of many scientific studies, it was concluded that the surface roughness could vary according to the composition of the restorative material [13,19]. It is also claimed that the materials with resin content show lower surface roughness values compared to those who do not contain resin [13]. The results of our study confirm this statement, as the conventional glass-ionomer cement Fuji IX GP proved to be the material with the highest surface roughness values (Tab.3).

Another common belief is that in addition to the presence of resin in the structure of the materials, the structure of the matrix, the amount, type and size of fillers also have a significant effect on the smoothness of the restorations [8,13,19]. The particle sizes of the filler of Estelite Sigma Quick, Dyract, Beautifil II and Fuji IX GP are as follows 0.2 μm, 0.8 μm, 0.8 μm, 10 μm, and the surface roughness values should increase in direct proportion to the increase in particle size. This dependence is present in the results of this study only for the glass-ionomer cement and it can be assumed that its significantly larger particle sizes contribute to its greater surface roughness. The results for the other three materials do not confirm the dependence of the surface roughness on the particle size of the filler (Tab.3). This is in line with other statements that materials with smaller particle sizes do not always exhibit a smoother surface. According to these authors' statements, other characteristics, such as shape, distribution and number of particles, as well as the bond between them, contribute to the smoothness and polish ability of the restorations [21]. The significantly smaller particle size of the nanocomposite Estelite Sigma Quick suggests the possibility of achieving a smoother surface with this material. The results of this study do not support this statement. Despite the reduction in particle size of these materials, there is evidence that no significant difference in surface roughness is found between them and microfilled composite materials [20]. There are different statements in the literature as to which surface roughness values are acceptable and which is the value beyond which the risk of biofilm accumulation and secondary caries lesion development increases significantly. Some authors claim that the critical value above which the retention, maturation and acid formation of MO significantly increase is 0.2μm [14,15,20,21]. According to others' opinion, the roughness of the fillings should be similar to or less than that of the enamel, which is 0.64 μm [19]. It is claimed that surface roughness below 10 μm is acceptable and that fillings with a roughness below 1 μm appear visually smooth [19]. According to the results of other studies, no significant difference was found in the accumulation of dental biofilm at values from 0.7 to 1.4 μm [21]. Taking into account these statements, it seems that the results obtained by us confirm that the materials, subject to our study, are clinically acceptable as restorative materials in terms of surface roughness. Only the glass-ionomer cement Fuji IX GP demonstrates higher values of surface roughness (average 0.9 μm, Table 2), which is in line with the results of many other studies on the surface roughness of various restorative materials [8,13,15].

Conclusion

Based on the results of this study, it can be concluded that the composition and particle size of the restorative materials actually affect their surface characteristics and their degree of polishability. Materials with smaller particle sizes and containing resin-Estelite Sigma Quick, Beautifil II and Dyract, demonstrate better polishability. Glass-ionomer cement is the material showing statistically significant higher surface roughness compared to the other three materials. However, this does not mean that Fuji IX GP is not a suitable material for restorations in the primary dentition, as long as indications for its application are followed.

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