© Borgis Nowa Stomatol 2019; 24(2):62-69 DOI: https://doi.org/10.25121/NS.2019.24.2.62

*Piotr Rożniatowski[1], Emil Korporowicz[1], Dariusz Gozdowski[2], Dorota Olczak-Kowalczyk[1]

The impact of oral hygiene, the intensity and increase of caries on the condition of Equia Fil glass ionomer and Tetric EvoCeram composite proximal restorations in permanent teeth

[1]Department of Paediatric Dentistry, Medical University of Warsaw
Head of Department: Professor Dorota Olczak-Kowalczyk, MD, PhD
[2]Department of Experimental Design and Bioinformatics, Warsaw University of Life Sciences
Head of Department: Professor Wiesław Mądry

Keywords

composite materials, glass-ionomer cements, risk factors, oral hygiene, permanent teeth

Summary

Introduction. Glass-ionomer cements and composite materials are widely used for direct restoration of carious lesions, also in young permanent teeth. However, knowledge on the effects of cariogenic factors on the quality of restorations performed using these materials, especially those covering proximal surfaces, which are more often exposed to bacterial plaque, is insufficient.

Aim. The aim of the study was to assess the impact of oral hygiene and increased intensity of caries on proximal composite and glass ionomer restorations in young permanent teeth after 2 years of usage.

Material and methods. Equia Fil glass-ionomer and Tetric EvoCeram composite restorations were performed in patients aged between 12 and 20 years with proximal carious lesions in premolars and molars. The clinical condition of restorations was assessed and indices such as OHI-S and D1-2DMFT (along with their increased values) were calculated at baseline, as well as during follow-up visits at 6, 12, 18 and 24 months. Correlations between clinical assessment of restorations and indices for oral hygiene and caries intensity, their increase and increased number of teeth with carious spots were evaluated.
The study was approved by the Bioethics Committee of the Medical University of Warsaw (No. KB/157/2013).

Results. A total of 100 proximal restorations were performed in 49 patients. After 24 months, 98 restorations (50 Equia Fil and 48 Tetric EvoCeram) were evaluated. Mean baseline OHI-S and D1-2DMFT were 1.37 and 12.04, respectively, for Equia Fil restorations, and 1.27 and 10.38 for Tetric restorations, with the following values reported during follow-up: 1.80 and 15.4; 1.63 and 12.38. Statistically significant relationships were found between OHI-S and values describing the state of materials. These values increased with increasing OHI-S and D1-2DMFT.

Conclusions. Both Tetric Evo Ceram and Equia Fil restorations are susceptible to cariogenic factors.

Introduction

The current guidelines of minimally invasive dentistry recommend selective removal of carious dentin, i.e. leaving residual demineralised dentin on the intrachamber wall followed by its sealing, preferably using materials that accelerate remineralisation of demineralised dentin to protect the pulp (1). Restoration of large two-surface lesions in lateral teeth requires an additional use of materials with high mechanical strength. For this reason, composite materials, which ensure stability and aesthetics, are very popular. However, these materials are not recommended for patients at high risk of caries, i.e. exposed to cariogenic factors. It was found that patients with high intensity of caries are more likely to develop secondary

caries and present with the loss of marginal adhesion of composite materials (2).

Temporary restorations using glass-ionomer cements are recommended for high-risk patients. Owing to their remineralisation properties, these materials are commonly used for restoring carious lesions, deep ones in particular. Insufficient mechanical strength is a factor limiting the use of conventional glass-ionomer cements for long-term restoration of proximal cavities in permanent teeth. Sensitivity to acids and worse aesthetics compared to composite materials are also important disadvantages. Currently available high-viscosity glass-ionomer cements show improved aesthetics and resistance to abrasion, as well as low solubility in the oral cavity (3-9). Covering these materials with a protective varnish containing nanofiller increases their smoothness, resistance to abrasion and hardness (10-13). At the same time, high-viscosity glass-ionomer cements show biocompatibility and the ability to release fluoride comparable to those of conventional ones. These properties suggest both longer use of restorations made of these materials, also when covering more than one surface, as well as benefits of their use in young permanent teeth showing higher dentin permeability, as well as in patients at high risk of caries. However, there is no sufficient evidence supporting this hypothesis in literature.

Dental plaque, new cavities and carious spots are objective indicators of restoration exposure to cariogenic factors (14). Very few studies assessed the effects of cariogenic factors or caries intensity on the performance of restorations made of different materials (2, 15).

Aim

The aim of the study was to assess the impact of oral hygiene and increased intensity of caries on proximal composite and glass ionomer restorations in young permanent teeth after 2 years of usage.

Material and methods

A randomised clinical study involving two types of intervention was conducted between 2013 and 2015. The interventions included a preliminary clinical and radiological assessment, follow-up examinations at 6-month intervals for 2 years, as well as Tetric EvoCeram (Ivoclar Vivadent, Schaan, Liechtenstein) composite (intervention A) or Equia Fil (GC, Tokyo, Japan) glass-ionomer (intervention B) proximal restorations in molars and premolars. The examinations were performed by two specialists in paediatric dentistry, each with more than 5 years of clinical experience, after appropriate training and calibration (Kappa coefficient: 0.89). The study was approved by the Bioethics Committee of the Medical University of Warsaw (No. KB/157/2013).

Recruitment was performed among patients reporting to the Department of Paediatric Dentistry of the Medical University of Warsaw. Inclusion criteria were as follows: age 12-20 years, proximal carious lesions in premolars or molars (Black class II; ICDAS II code 4 or 5, radiographic caries depth D1, D2 or D3 according to Manji et al.), and a written consent from the patient/parent or legal guardian to participate in the study. Exclusion criteria were as follows: secondary caries, signs of pulpitis in a tooth with a proximal cavity (pain, inappropriate response to dental pulp tests), parafunctional tooth-clenching (bruxism), malocclusion, ongoing or planned orthodontic treatment, history of chronic disease requiring specialist medical care, planned change of residence during the year.

According to the principle of randomisation, a block-size of 6 was used to allocate patients for two types of interventions. The codes for interventions (A, B) were assigned to the numbers of teeth (n), in accordance with the order of reporting. If more than one tooth was qualified in a given patient, the order of intervention was determined by the location of the tooth in the oral cavity – tooth 16 first, then teeth 26, 36 and 46. Blinding of the intervention was achieved by placing randomisation results in opaque envelopes. The use of allocation concealment allowed for the protection of randomisation and prevented access to information about the group to which the patient was allocated before inclusion in the study.

Class II cavities were treated according to the principles of minimally invasive dentistry, i.e. leaving residual demineralised dentin. Matrix bands 0.045 mm were used for tooth shape restoration, and lignin rolls were used for treatment site isolation (13, 16-20). The materials were applied in accordance with manufacturers' instructions. Tetric EvoCeram was applied using the layered technique, while a single-layer method was used for Equia Fil. In the case of composite materials, surface finishing was done immediately after application. For Equia Fil, surface finishing was done 2.5 minutes after the beginning of mixing. The surface was covered with Equia Coat and light-cured for 20 seconds.

Clinical examinations were performed in a dental office setting (21, 22). Baseline and follow-up examinations were performed to assess both oral hygiene using oral hygiene index simplified (OHI-S) for dental plaque according to Green and Vermillion (1964), and dentition – the presence of caries on all tooth surfaces according to the International Caries Detection and Assessment System (ICDAS-II). D1-2DMFT was calculated, with ICDAS II code 1 and 2 taken as D1 and ICDAS II ≥ 3 taken as D.

Restorations were assessed after a month and during follow-up, using a 5-point scale, as in accordance with the criteria developed by Hickel et al., and recommended by the World Dental Federation (FDI) (23, 24) (tab. 1).

Patients were provided with dietary and hygiene advice, as well as had fluoride varnish applied during visits.

Tab. 1. Hickel's criteria for the assessment of dental restorations

Clinical condition	Excellent, very good	Good	Sufficient, satisfactory	Unsatisfactory	Poor
Surface discolouration	none	mild, easily removable discolouration	moderate surface discolouration, including other teeth, aesthetically acceptable	unacceptable surface discoloration, greater intervention needed	severe unrepairable discoloration
Retention and cracking	none	hairline fractures	larger cracks with no effects on marginal sealing or the contact point	cracks affecting sealing or the contact point, massive cracks with the loss of more than 50% of filling	partial or total loss of filling
Marginal adaptation	no gaps or discolouration	marginal gap removable by polishing	marginal gap cannot be removed by polishing, minor cracks in the enamel or dentin	exposed dentin, fracture gap compromising marginal sealing and exposing dentin	loose restoration
Post-operative hypersensitivity/tooth vitality	viable tooth, no hypersensitivity	mild, transient hypersensitivity, viability maintained	no subjective symptoms, reduced or delayed response to stimuli, no need for treatment	increased, longer-lasting response, symptoms reported	symptomatic pulpitis, pulp necrosis, endodontic treatment needed
Secondary caries, erosion, abfraction	none	very mild, in situ; demineralisation, abfraction, correction not needed	large surfaces of demineralization, erosion, abfraction, no dentin exposure, no need for intervention	undermining caries, erosions, abfraction, dentin abrasion, repairable	deep secondary caries, exposed dentin, unrepairable

Statistica 12 (StatSoft) for Windows (Microsoft) was used for statistical analysis. A $p \leq 0.05$ was considered significant for all calculations. Data for statistical evaluations was obtained from previously prepared Excel spreadsheets (Microsoft). T-student test was used to compare mean OHI-S, D1-2DMFT, increased D1-2T and the number of patients with an increased number of carious spots for interventions A and B, as well as mean D1-2DMFT, D1-2T, OHI-S and their increase for the individual materials rated excellent within 24 months. The U-Mann-Whitney test was used to compare the mean values from the assessment of materials in the individual categories, while chi-square test was used to compare the numbers of restorations with Hickel's score of less than 1 for a given category. Spearman's rank correlation coefficients were determined to assess the correlations between clinical findings for the tested materials (mean scores) and mean OHI-S for each patient throughout the study period, baseline D1-2DMFT, as well as an increase in OHI-S, D1-2DMFT and D1-2T.

Results

A total of 49 patients aged between 12.08 to 19.58 years (mean age 15.87 ± 1.80), in whom 100 proximal restorations in 46 premolars and 54 molars (64 maxillary and 46 mandibular) were performed, were included in the study. A follow-up of 98 restorations, including 50 Equia Fil and 48 EvoCeram restorations, was performed after 24 months. The lower number of restorations assessed during follow-up was due to patient failure to report.

The mean number of teeth present in the oral cavity was 27.95 (± 0.297). Mean values for OHI-S and D1-2DMFT at baseline and during follow-up after 24 months, along with the number of patients with increased number of carious spots are shown in table 2. Mean Hickel scores for materials assessed after 24 months, along with the number of restorations with a score other than excellent and intergroup differences are shown in table 3. Spearman's correlation coefficients reflecting the relationships between caries indices and OHI-S at baseline and after 24 months, as well as between changes of these indicators and restoration scores are shown in table 4. Since no erosion or secondary caries were observed in the teeth restored with composite material, these were not included in the calculation of correlations.

Table 5 shows mean D1-2DMFT, D1-2T, OHI-S and their increase at 24-month follow-up vs baseline in patients with restorations scored as excellent in accordance with the used scale.

Tab. 2. OHI-S and D1-2DMFT at baseline and at 24-month follow-up, the number of patients with increased number of carious spots within 24 months

Clinical parameters		Equia		Tetric		P	
		Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
OHI-S	mean ± SD	1.37 ± 0.54	1.80 ± 0.62	1.27 ± 0.54	1.63 ± 0.53	0.339	0.149
D1-2DMFT	mean ± SD	12.04 ± 5.84	15.41 ± 7.51	10.38 ± 3.98	12.38 ± 4.68	0.100	0.019*
Increased D1-2T	mean ± SD	–	2.00 ± 1.84	–	1.40 ± 1.50	–	0.079
Increased D1-2T, number of patients (%)	N (%)	–	33 (67.3%)	–	34 (70.8%)	–	0.710

*statistical significance, p ≤ 0.05

Tab. 3. Mean scores obtained by the assessed materials for the individual categories after 24 months

Category	Tetric EvoCeram	Equia Fil	P
	Mean ± SD		
Clinical condition	1.208 ± 0.410	2.083 ± 0.647	< 0.001*
Discolouration	1.208 ± 0.410	1.917 ± 0.577	< 0.001*
Retention/cracks	1.000 ± 0.000	1.042 ± 0.289	0.863
Marginal adaptation	1.042 ± 0.202	1.396 ± 0.707	0.048*
Secondary caries/erosion	1.000 ± 0.000	1.354 ± 0.601	0.014*
	Number of restorations scored > 1 n/%		P
Clinical condition	10 (20.8%)	40 (83.3%)	< 0.001*
Discolouration	10 (20.8%)	38 (79.2%)	< 0.001*
Retention/cracks	0 (0.0%)	1 (2.1%)	0.315
Marginal adaptation	2 (4.2%)	13 (27.1%)	0.002*
Secondary caries/erosion	0 (0.0%)	14 (29.2%)	< 0.001*

*statistical significance, p ≤ 0.05

Discussion

Our findings indicate that oral hygiene is an important factor affecting dental restorations, glass-ionomer restorations in particular. Spearman's correlation analysis showed the impact of dental plaque on the clinical condition of both composite and glass-ionomer restorations. A strong positive correlation was found between OHI-S and the general condition of restorations. Increasing OHI-S correlated with a higher category of the general assessment of restorations. This correlation was statistically significant for both composite and glass-ionomer restorations, with a stronger correlation for Equia Fil, indicating greater dependence of its quality on oral hygiene compared to composite restorations. Also, a relationship was confirmed between discolouration of composite and glass-ionomer cements and the loss of marginal adaptation of Equia Fil restorations and OHI-S. A positive correlation was also found between increased OHI-S and erosions. Erosion of glass-ionomer cements was observed in patients with higher OHI-S, and the relationship was statistically significant. Also, statistically significant differences were found in D1-2DMFT, D1-2T, OHI-S and increased values of these parameters between patients with composite restorations rated excellent and patients with glass-ionomer restorations scored 1 according to Hickel's scale. Significantly higher values for the above mentioned indices were reported in the first group. This provides evidence for the poor condition of Equia Fil restorations in patients with higher intensity of caries, poor oral hygiene and a higher number of carious spots.

Tab. 4. Spearman's correlation coefficients showing the relationships between caries indices, hygiene and increased OHI-S, D1-2DMFT, D1-2T and features regarding the assessment of restorations at baseline and after 24 months

Clinical parameters	Clinical condition		Discolouration		Marginal adaptation		Retention/ cracks	Erosion
	Tetric	Equia	Tetric	Equia	Tetric	Equia	Equia	Equia
OHI-S (baseline)	0.250	0.526*	0.250	0.415*	-0.169	0.462*	0.197	0.160
OHI-S (follow-up)	0.314*	0.719*	0,314*	0.537*	-0.167	0.500*	0.090	0.274
Increased OHI-S	0.138	0.413*	0.138	0.262	-0.030	0.131	-0.165	0.293*
D1-2DMFT (baseline)	0.094	0.383*	0.094	0.467*	-0.004	-0.017	-0.185	0.410*
D1-2DMFT (follow-up)	0.340*	0.565*	0.340*	0.546*	0.008	0.241	-0.137	0.490*
Increased D1-2DMFT	0.418*	0.668*	0.418*	0.359*	0.089	0.601*	0.028	0.397*
Increased D1-2T	0.535*	0.567*	0.535*	0.477*	0.035	0.477*	0.070	0.407*

*statistical significance, $p \leq 0.05$

Tab. 5. Mean (± SD) indices for Equia Fil and Tetric EvoCeram rated excellent during the 24-month period

	Clinical condition = 1		
	Equia (± SD)	Tetric (± SD)	P
D1-2DMFT	5.50 ± 1.51	7.47 ± 2.21	0.021*
Increased D1-2DMFT	0.13 ± 0.35	0.55 ± 1.03	0.257
D1-2T	1.13 ± 1.81	3.87 ± 2.30	0.003*
Increased D1-2T	0.00 ± 0.53	0.92 ± 1.00	0.015*
OHI-S	0.79 ± 0.50	1.54 ± 0.49	< 0.001*
Increased OHI-S	-0.15 ± 0.46	0.36 ± 0.51	0.013*

*statistical significance, $p \leq 0.05$

Kemoli and Amerongen (25) assessed glass-ionomer proximal ART restorations in primary teeth. Restorations were performed using glass-ionomer cements: Fuji IX (GC Europe) and Ketac Molar Easymix/Ketac Molar Aplicap (3M ESPE AG, Germany). Plaque index was assessed at baseline and after 2 years. Patients with a mean plaque index below 1.5 presented with better condition of restorations compared to patients with higher values. However, the difference was not statistically significant.

The condition of restorations was also correlated with dental health in the study group. Patients with higher D1-2DMFT presented with significantly worse condition of restorations. This correlation was statistically significant for both types of restorations. A positive statistically significant correlation was demonstrated between increased D1-2DMFT and its component D1-2T and a higher category for the state of Tetric EvoCeram and Equia Fil restorations over the 24-month period. A strong correlation was observed between increased D1-2DMFT during the 2-year period and erosion, as well as worse marginal adaptation for glass-ionomer restorations. No studies assessing the effects of caries intensity and increased D1-2DMFT (and its components) on the condition and maintenance of restorations may be found in literature. However, McKenzie et al. (26) confirmed the susceptibility of glass-ionomer materials to acids in their *in vitro* study. The authors incubated conventional and resin-modified glass-ionomer samples in saliva, saline, coca-cola and juices (orange and apple juice). After 3 months, erosions on the surface of conventional glass-ionomer materials and reduced strength were observed; samples stored in juices dissolved after a year. This supports the thesis

on the susceptibility of glass-ionomer materials to acids. Increased intensity of caries and new carious spots indicate the presence of cariogenic plaque, in which acids, which are the product of bacterial metabolism, compromise the strength and hardness of materials, as well as alter their surface structure as a result of erosion. This promotes cracks, discolouration due to the accumulation of dyes in the eroded surface and general impairment of physical properties of these materials. The same mechanisms were probably responsible for the deteriorated condition of restorations in our study.

Long-term observations indicate that secondary caries is the most common reason for replacing composite restorations. According to literature reports, this is mainly due to cariogenic bacteria accessing the restored lesion through microcracks and a gap at the border of material and mineralised dental tissue, which forms as a result of polymerisation shrinkage. No secondary caries was observed in our study. Similar results were obtained by other researchers. However, a positive statistically significant correlation was found between increased caries and carious spots and deteriorated general condition of composite restorations. This supports data in the cited literature, indicating that failures to maintain composite restorations are more common in patients at an increased risk of caries (27-29).

Opdam et al. (30) determined the risk of caries in patients based on the presence of new carious lesions during their 20-year observations of Black class II composite and amalgam restorations. They reported failure in 55.9% of high-risk patients and 22.1% of other patients.

According to a cross-sectional study conducted by Sunnegardh-Gronberg et al. (31), patients at a high risk of caries needed earlier replacement of restorations (on average every 5 years) compared to moderate-to-low risk patients (every 7 years). Class II restorations were replaced every 4 and 6 years, respectively.

In their retrospective study, Opdam et al. (18) compared the efficacy of open-sandwich class II restorations using glass-ionomer and composite materials vs total-etch composite restorations. The authors assessed the risk of carious disease in patients based on medical records covering a period of 9 years, including their socioeconomic status. They reported 2% of failures due to recurrent caries in low-risk patients with composite restorations, and 16% of failures in high-risk patients. The difference was statistically significant. Failure rates due to secondary caries were higher for open-sandwich restorations. They were 6 and 26% in patients at low and high risk of caries, respectively.

The relationship between the condition of restorations and caries intensity was assessed by Kogler et al. (2) and Trachtenberg et al. (15). Kohler et al. qualified 17.6 and 27.6% of class II Superlux Molar (the DMG system; Dental Material Gesellschaft mbH, Hamburg, Germany) restorations in permanent teeth for replacement after 3 and 5 years, respectively. However, the final result also included restorations classified as unacceptable after 3 years of usage. The authors did not exclude them from calculations. Most restorations (44%) were replaced due to recurrent caries, 25% due to the loss of marginal attachment. Similarly to our observations, the authors found that higher Ryge's scores were accompanied by higher DMFS. However, they performed no statistical analysis to assess the relationship between this index and the condition of restorations.

Trachtenberg et al. (15) made an attempt to assess a correlation between the intensity of caries and the need to replace restorations in lateral primary and permanent teeth. The researchers assessed DFT/dft, DFS/dfs during a visit when restorations were performed. The teeth missing due to caries were not included in the analysis. Composite, compomer and amalgam were used for restorations. Restorations were then assessed for recurrent (secondary) caries, fractures, loss of filling, and the presence of new carious lesions in the evaluated teeth. After 5 years, 6% of all restorations were replaced due to secondary caries. The authors found statistically significant correlations between the number of replaced restorations and DFT/dft, DFS/dfs, which corresponds to our findings. However, it seems that an analysis for the risk of caries, in which not only carious lesions, but also carious spots are considered, is more valuable. An assessment of the relationship between the condition of restorations and increased intensity of caries is also important. The presence of new carious spots indicates persistent exposure to cariogenic factors. A correlation analysis of D1-2DMFT and D1-2DMFS alone fails to provide full information on the impact of cariogenic factors as the value of this index may consist mainly or only of the F component. Furthermore, it does not reflect oral conditions during the use of restorations.

Conclusions

Both, Tetric EvoCeram composite and Equia Fil glass-ionomer restorations are susceptible to cariogenic factors, as indicated by the statistically significant relationship between their condition and increased intensity of caries. The condition of Equia Fil restorations is dependent on oral hygiene to a greater extent.

Conflict of interest

None

Correspondence

*Piotr Rożniatowski
Zakład Stomatologii Dziecięcej
Warszawski Uniwersytet Medyczny
ul. Miodowa 18, 00-246 Warszawa
tel.: +48 (22) 502-20-31
prozniatowski@wum.edu.pl

References

1. Leal SC: Minimal intervention dentistry in the management of the paediatric patient. Br Dent J 2014; 216(11): 623-627.
2. Kohler B, Rasmusson CG, Odman P: A five-year clinical evaluation of class II composite resin restorations. J Dent 2000; 28: 111-116.
3. Ngo HC, Mount G, Mc Intyre J et al.: Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: an *in vivo* study. J Dent 2006; 34(8): 608-613.
4. Dalli M, Çolak H, Mustafa Hamidi M: Minimal intervention concept: a new paradigm for operative dentistry. J Investig Clin Dent 2012; 3(3): 167-175.
5. Gao W, Smales RJ, Yip HK: Demineralisation and remineralisation of dentine caries, and the role of glass-ionomer cements. Int Dent J 2000; 50(1): 51-56.
6. Frankenberger R, Sindel J, Krämer N: Viscous glass-ionomer cements: a new alternative to amalgam in the primary dentition? Quintes Int 1997; 28(10): 667-676.
7. Nagaraja UP, Kishore G: Glass ionomer cement – the different generations. Trends Biomater Artif Organs 2005; 18(2): 158-165.
8. Wiegand A, Buchalla W, Attin T: Review on fluoride-releasing restorative materials – fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater 2007; 23(3): 343-362.
9. Costa CA, Nascimento AB, Teixeira HM: Response of human pulps following acid conditioning and application of a bonding agent in deep cavities. Dent Mater 2002; 18: 543-641.
10. Bonifácio CC, Werner A, Kleverlaan CJ: Coating glass-ionomer cements with a nanofilled resin. Acta Odontol Scand 2012; 70(6): 471-477.
11. Gurgan S, Kutuk ZB, Ergin E et al.: Four-year randomized clinical trial to evaluate the clinical performance of a glass ionomer restorative system. Oper Dent 2015; 40(2): 134-143.
12. Diem VT, Tyas MJ, Ngo HC et al.: The effect of a nano-filled resin coating on the 3-year clinical performance of a conventional high-viscosity glass-ionomer cement. Clin Oral Investig 2014; 18(3): 753-759.
13. Friedl K, Hiller KA, Friedl KH: Clinical performance of a new glass ionomer based restoration system: a retrospective cohort study. Dent Mater 2011; 27(10): 1031-1037.
14. Guideline on Caries-risk Assessment and Management for Infants, Children, and Adolescents. The American Academy of Pediatric Dentistry, 2014; http://www.aapd.org/media/policies_guidelines/g_cariesriskassessment.pdf.
15. Trachtenberg F, Maserejian NN, Tavares M et al.: Extent of tooth decay in the mouth and increased need for replacement of dental restorations: the New England Children's Amalgam Trial. Pediatr Dent 2008; 30: 388-392.
16. Ivoclar Vivadent 2017: Instructions for use Tetric EvoCeram; www.ivoclarvivadent.com/en/p/all/products/restorative-materials/composites/tetric-evoceram.
17. Gurgan S, Kutuk ZB, Ergin E et al.: Clinical performance of a glass ionomer restorative system: a 6-year evaluation. Clin Oral Investig 2017; 21(7): 2335-2343.
18. Opdam NJ, Bronkhorst EM, Roeters JM, Loomans BA: Longevity and reasons for failure of sandwich and total-etch posterior composite resin restorations. J Adhes Dent 2007; 9: 469-475.
19. Ernst CP, Martin M, Stuff S, Willershausen B: Clinical performance of a packable resin composite for posterior teeth after 3 years. Clin Oral Investig 2001; 5: 148-155.
20. GC Europe 2017: Instructions for use Equia Fil & Coat; www.gceurope.com/products/equia.
21. World Health Organization: Goals for oral health in the year 2000. Brit Dent J 1982; 5: 21-22.
22. World Health Organization: Oral health surveys: basic methods. 5th ed. Geneva 2013.
23. Hickel R, Roulet JF, Bayne S et al.: Recommendations for conducting controlled clinical studies of dental restorative materials. Clin Oral Invest 2007; 11: 5-33.
24. Hickel R, Roulet JF, Bayne S et al.: FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect restorations – update and clinical examples. Clin Oral Invest 2010; 14: 349-366.
25. Kemoli AM, Amerongen WE: Effects of oral hygiene, residual caries and cervical Marginal-gaps on the survival of proximal atraumatic restorative treatment approach restorations. Contemp Clin Dent 2011; 2(4): 318-323.

26. McKenzie MA, Linden RW, Nicholson JW: The physical properties of conventional and resin-modified glass-ionomer dental cements stored in saliva, proprietary acidic beverages, saline and water. Biomaterials 2003; 24(22): 4063-4069.
27. Bohaty B, Ye Q, Misra A et al.: Posterior composite restoration update: focus on factors influencing form and function. Clin Cosmet Investig Dent 2013; 5: 33-42.
28. Drummond JL: Degradation, fatigue and failure of resin dental composite materials. J Dent Res 2008; 87(8): 710-719.
29. Feng X: Cause of secondary caries and prevention. Hua Xi Kou Qiang Yi Xue Za Zhi 2014; 32(2): 107-110.
30. Opdam NJ, Bronkhorst EM, Loomans BA, Huysmans MC: 12-year survival of composite vs. amalgam restorations. J Dent Res 2010; 89: 1063-1067.
31. Sunnegardh-Gronberg K, van Dijken JW, Funegard U et al.: Selection of dental materials and longevity of replaced restorations in Public Dental Health clinics in northern Sweden. J Dent 2009; 37: 673-678.

submitted:
25.02.2019
accepted:
23.05.2019