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RESEARCH ARTICLE

Cervical Caries: Modern Methods of Diagnosis and Treatment

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Abstract

Objective: The purpose of this study is to study the effectiveness of the cervical caries treatment when filling with different materials in the short and long term. *Methods*: To study the elemental composition, electron probe microanalysis method was used. The quality of fillings from NC, GC, CM was evaluated in the following terms: a week after restoration, six months, a year, two years. *Results*: Features of the anatomical structure of the cervical region indicate an increased risk of caries here. Areas with increased tissue hardness, as well as hardness, stability and mineralization may form in the dental tissue. These foci are able to withstand the demineralization of the tooth for some time. *Conclusions*: When filling NC and CM in the intermediate layer between dentin and material, the structure is homogeneous. The hard tissues of the tooth are enriched due to the contained fluorides. Scanning microscopy data confirmed the opening of the dentinal tubules. The first group of patients (low resistance to caries) improved 1.4 times the performance of the marginal fit of the fillings, provided that ozonation was present ($p \leq 0.05$). For the second group, the safety of fillings was established for 2 years in 95% of cases, but subject to the presence of ozonation.

Keywords: *Cervical caries, Ozonation, Nanocomposites, Glass ion cements, Nanoglassionomer, compomer.*

Introduction

For caries, the occurrence of such irreversible processes as demineralization of the tooth hard tissues is characteristic [1, 2]. In the process of demineralization, softening of hard tissues occurs, followed by the formation of a carious cavity [3]. The main cause of tooth decay is a bacterial infection [4]. Caries is one of the most common diseases of mankind, occurring in varying degrees of difficulty in 95% of people. Caries accompanied a person 2-2.500 years BC, as established by archaeological research.

At the same time, the state of teeth in people in the 9-12 centuries of our era was much better than in modern ones, caries was noted in only 3%. [5].The main reason for the spread of caries in the modern world (and this trend was observed 50-80 years ago) is a change in diet and diet [6]. In the modern diet, carbohydrates are becoming increasingly important, according to the World Health Society, sugar consumption has increased 10-fold over the past hundred years [7].Complications arising from the development of caries can lead to the formation of foci of infection and deterioration in the general condition of the body. Caries prevention and treatment are very expensive procedures. The budget of the corresponding dental services in the USA alone for the year is on average about $30 billion, which is comparable to the annual budgets of individual states [8].Localization of caries is of three types [9].

The first group includes the so-called fissure-pit caries, which is associated with the corresponding area of the tooth. The second type, approximate caries, is associated with other factors, namely, with crowded teeth, as well as non-compliance with oral hygiene conditions. Finally, cervical caries is a consequence of gum disease and periodontal disease. Localization of cervical caries in an inaccessible zone makes hygienic procedures

ineffective and contributes to its development. At the transition to the root cement, the enamel is especially thin, which also contributes to the development of the carious process in this area of the tooth. The market for dental products is constantly updated with new materials. In modern dentistry, the so-called composite materials used as the main material for fillings are popular. These materials are widely used among dentists and popular among patients, which is associated with several factors. They include the undoubted aesthetics of the material itself, as well as adhesive properties, i.e., the ability to firmly bond with tooth tissues. Modern composites (C) are able to withstand a significant occlusal load, which preserves the gloss, as well as such properties of dental tissues as features of the anatomical structure, nuances of color [10].Despite all the above advantages, the use of composites in some cases may be limited.

These factors include: a) the rapid dynamics of the carious process; b) caries in the teeth, in which the mineralization process has not ended; c) the abnormal structure of the hard tissues of the tooth. In general, in the treatment of cervical caries, the features of non-carious lesions of cervical localization, the possibility of carious processes in the roots of the teeth should be taken into account. All of the above requires the use of other types of materials, such as glass ionomer cements (GC), as well as compomers (CM).In favor of GC in the treatment of cervical caries, such properties as a high degree of adhesion of GC and tooth tissues (enamel and dentin), as well as diffusion of the fluorine contained in them in these tissues [11] are in favor.

GCs are also biocompatible with tooth tissues. An important property of GC is the coefficient of thermal expansion close to dental tissues, as well as the absence or low rates of polymerization shrinkage and the elasticity of the material itself. Yet GC is not a universal material. Among the disadvantages of GC, first of all, the lack of polishing gloss should be indicated, which reduces the aesthetics of this material, as well as low strength compared to the same C (composites).CM (another name is polyacid composites) is a relatively newly used type of material in dentistry, since 1990s. This type of material is characterized by a combination of C and GC characteristics. They are similar to composites by the saturation of the color gamut, low viscosity indices, as well as plastic properties, uniformity of composition and, as a result, polish ability. Distinctive features of CM are its high strength indicators compared to GC. GC and CM are similar to a high degree of adhesion, the similarity of the thermal coefficient of expansion to that of hard tooth tissues, the ability to diffuse fluorides in them, and low solubility. The latter determines the slower destruction of fillings compared to other materials [12, 32].In modern dental technologies; the processing of hard tooth tissues by various active substances (ozone and others) is actively used. The disadvantage of this technology is the lack of information about the processes and reactions that occur at the micro level. A key role in such reactions is played by such factors as the structure of the tooth surface and its topology.

During tooth filling, including those affected by cervical caries, a hybrid zone is formed, which is a transition between the hard tissues of the tooth and the material used in the filling. Nevertheless, in the available literature, a complete comparison of the quality of materials widely used in filling teeth affected by cervical caries has not been carried out [13, 14]. The available information is fragmentary, devoted to any one material or technology for the treatment of cervical caries, or other types of caries are the object of study [4, 15]. The specific features of cervical caries in this case, of course, are not taken into account. All of the above determined the relevance of this work.

The purpose of this study is to study the effectiveness of the treatment of cervical caries when filling with different materials in the short and long term. The objectives of the study were: a) to study changes in the composition of trace elements when filling cavities of the cervical localization with different materials; b) assess the morphology and structure of dentin after ozonation; c) to study the shelf life of seals from different materials, taking into account ozonation in the short and long term; d) based on the above tasks, to develop an algorithm for the successful treatment of caries of cervical localization in relation to the resistance of teeth to caries.

Materials and Methods

Materials and Methods of Laboratory Research

The studies were conducted in 2015-2019 at the Sechenov First Moscow State Medical University, and the Department of Orthopedic Dentistry of the Central Research Institute of Dental and Maxillofacial Surgery of Ministry of Health of Russia, Moscow, Russian Federation. We assigned materials and research methods to a separate block, since they correspond to the tasks set. Separately, we placed the methods of clinical examinations and a subsection of statistics.

To study the elemental composition during filling, the method of electron probe microanalysis was used. This part of the research was performed at the Institute of Geology of the Russian Academy of Sciences. A total of 40 teeth were selected, 10 in each group. We used teeth affected by carious changes equally. All teeth belonged to the second molars of the upper and lower jaws. The nanoglassionomer brand (hereinafter - NGI) is Ketak N-100, the CM brand is Dyract extra, the GC brand is Vitremer, the nanocomposite brand (NC) is Filtek Supreme XT. Carious cavities of cervical localization were sealed with these materials. Then we performed the creation of thin sections from the teeth, the thickness of each thin section of longitudinal orientation is 1-2.0 mm. Using the electron-probe analyzer Cameca SX 100, the composition of trace elements, namely calcium, phosphorus, sulfur, fluorine, magnesium, sodium, chlorine, and silicon, was studied. We studied the differences in the content of these trace elements, as well as the structural features of the intermediate zone located at the border of the filling material and the hard tissue of the tooth.

After ozonation, the method of scanning electron microscopy (Jeol JSM-6390LV microscope) was used to assess the structural features and morphology of dentin. The material was prepared using a drill with a low speed and a diamond disk. Similar sections were made. These sections were sawn into 4 or 5 equal-sized sectors, which were subjected to electron microscopy (Fig. 1.).

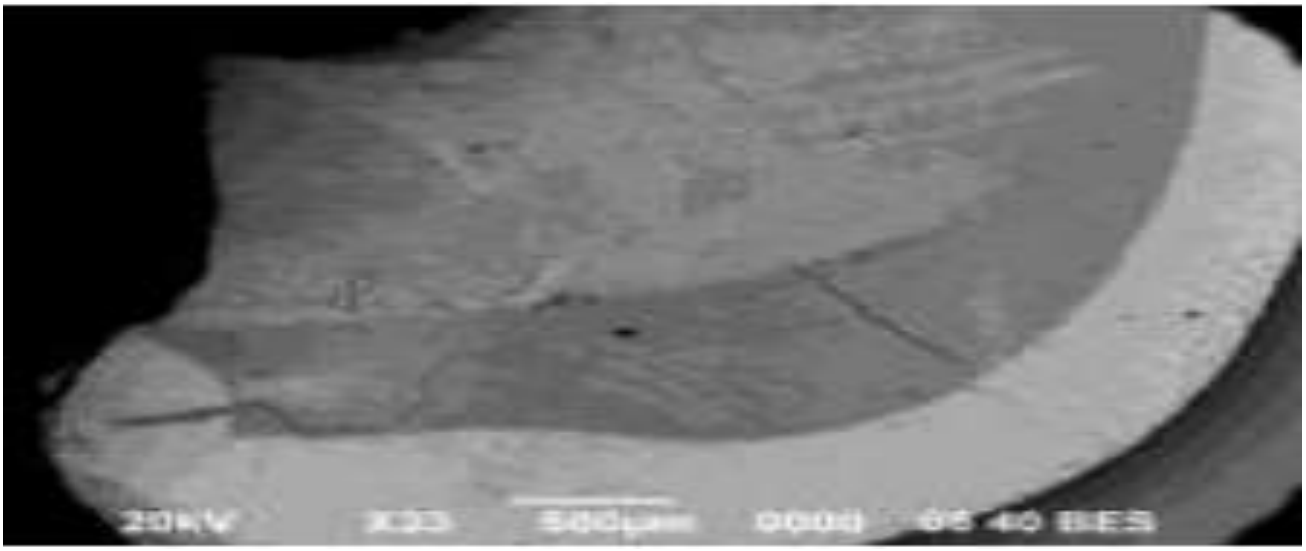

Fig. 1: Photograph of a thin section sample obtained by scanning electron microscopy

Scanning direction - from enamel to tooth pulp. Scanning was carried out after carbon spraying. After the first scan, the ozonation process was carried out for 6 seconds, and the samples were re-scanned. During both the first and second scans, the material was in medium simulating saliva.

Clinical Researches

Clinical studies were carried out in the period 2015-2019, on the basis of the Department of Orthopedic Dentistry of the Central Research Institute of Dental and Maxillofacial Surgery of the Ministry of Health of Russia, Moscow, Russian Federation. The study involved 160 patients. Each patient was examined, probed; the history and complaints of the patient were taken into account. Used additional methods, such as electrometry, thermal tests, as well as electrodontometry. Everyone was diagnosed with cervical caries, grade 5, according to Black, the diagnosis of ICD-10, K02.1. The distribution of patients by age and gender is presented in Table.1.

Table 1: Age and gender composition of patient groups

Age group, years	Male	Female
18-20	5	3
21-30	15	11
31-40	41	49
41-50	14	22
Number, people	75	85

The average age of males was 34.7±1.5, and of females 37.1±1.7 years. About half of the patients (without differences in gender and age criteria) had low resistance to caries (78 people, group 1), the remaining 82 had a moderate degree (group 2).The quality of the fillings was evaluated in the following terms: a week after restoration, six months, a year, two years

Statistical Analysis

Processing of the results was carried out using the program Origin v. 8.0, as well as the statistical analysis package Microsoft Excel 2010. Student t-test was used, as well as Student criterion for multiple comparisons (taking into account the Bonferroni correction, at $p \leq 0.05$).

Results

An analysis of the results of scanning electron microscopy showed that NC has the most homogeneous microstructure (Fig. 2B). This microstructure is characterized by fine-grained, as well as an adhesion layer thickness of about 50 mCM. For NGI (Fig. 2A), sphere-like inclusions are noted, but they occur singly. CM (Fig. 2C) forms a layer similar in structure to NC, but less homogeneity of the transition zone is noted for this layer.

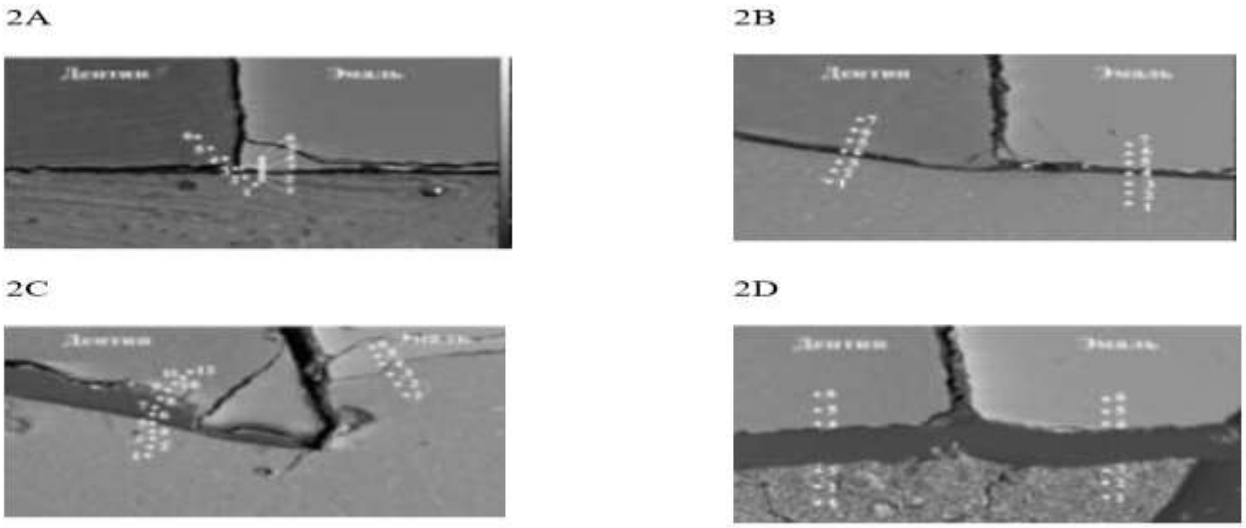

Fig. 2: Electronic scans of thin sections with filling with various materials. 2A - nanoglassionomer (NGI), 2B - nanocomposite (NC), 2C - compomer (CM) 2D - glass ionomer (GC)

Finally, GC forms an undifferentiated and heterogeneous structure. This material is also characterized by the maximum thickness of the transition layer. Large particles are found in the layer, from which cracks extend deep into the material of the seal. The content of certain trace elements, in particular fluorine, is high in GC, as well as in CM. The content of other trace elements, in particular silicon, is maximum in two other types of materials, namely NGI and NC. The high content of fluorine compounds in GC and CM compensates for their deficiency in the surrounding hard tissues of the tooth, as shown by the analysis. The content of calcium and phosphorus was also found to be low in dentin and enamel. Calcium deficiency, of course, is a consequence of the ongoing carious processes in the hard tissues of the tooth of the cervical localization. For the remaining trace elements, no significant difference was established. Our results of electronic scanning indicate a higher quality of NC and CM compared to two other materials, which consists in good transition zone characteristics, as well as the homogeneity of the layer itself. The filling of CM and GC increases the content of fluorine compounds in the hard tissues of the tooth. At a slight increase, up to 1500 (Fig. 3A), that the micro relief of the tooth is formed by grooves that remain from the preparation of the tooth. With a large increase (2500), it becomes apparent that the dentin tubules and the main substance form the basis of the dentin layer structure. Dentin tubes pass through the entire dentin layer, from the border with enamel to the inner surface of the dentin (Fig. 3B).

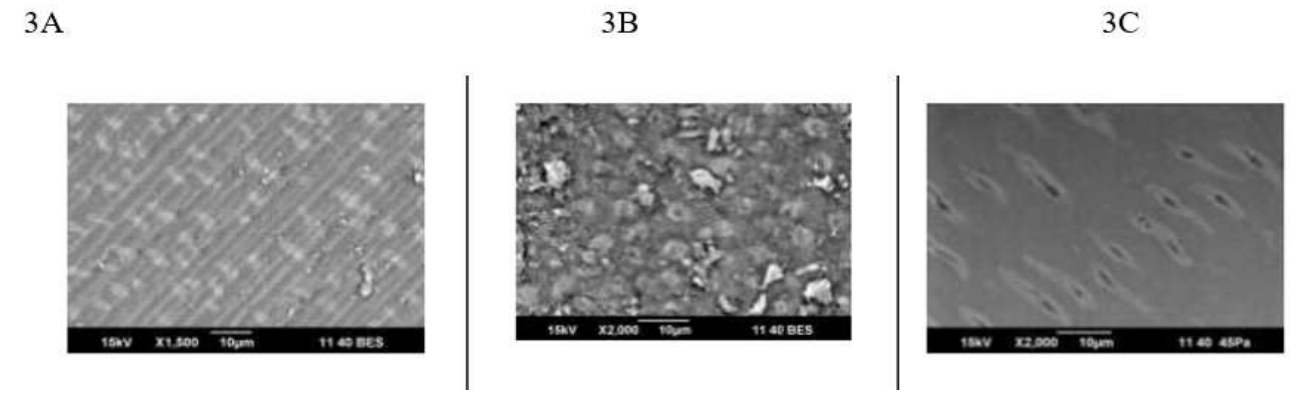

Fig. 3: The structural features of the micro relief of the dentin surface before and after ozonation (increase of 1500). 3A is the microrelief of the dentin surface before ozonation begins; 3B is a layer without clear boundaries on the dentin surface; 3C - microrelief of the dentin surface after ozonation

The distribution of the tubules in different layers of dentin is uneven, for example, in the dentin near the pulp there are at least 32-39 in the field of view, while in the outer layers, their number is 2.0 times smaller ($p \leq 0.05$). After the ozonation process, the dentinal tubules open (Fig. 3C). It should be noted that damage to the tubules, as well as dentin microrelief after ozonation, was not detected. The fuzzy layer also disappears. This indicates the safety of ozonation as an accompanying process in dental procedures. We found significant differences ($p \leq 0.05$) between groups of patients with low and medium resistance to caries.

Table 2: The condition of the oral cavity in patients according to various index systems (* - differences are significant at $p \leq 0.05$)

	Low stability		High stability	
	Before therapy	After therapy	Before therapy	After therapy
DMF index	12.7±1.5	12.6±1.4	7.4±0.6	7.5±0.7
OHI-S index	1.85±0.20	0.98±0.18*	0.80±0.05	0.39±0.02*
CPI index	2.60±0.21	1.95±0.10*	1.47±0.21	1.18±0.06*

After therapy, improvements were recorded for the hygiene as well as the periodontal index (Table 2). For patients with an average level of resistance, the indicators of the hygiene index correspond to a normal level, and obvious improvements in the oral cavity occurred in patients with a low level of resistance. The same was noted for patients of both groups in terms of periodontal status. Improvements in the reduction or absence of gum bleeding and quantitative indicators of hard and soft dental deposits were also noted. Different results were obtained when filling with different types of fillings (Table 3). For group 2, the most optimal result was obtained for materials based on NC and CM. At the same time, in group 1, the best results were obtained for CM.

Table 3: Indicators of electrometry in the short and long periods for patients with low and medium degrees of resistance to caries ($p \leq 0.05$)

Group	Material	Together	Week	Month	6 months	Year	Two years
Low stability	Filtek Ultimate, NC	4.4±0.02	0.8±0.01	1.3±0.01	1.7±0.02	2.2±0.03	3.5±0.03
	Dyract Extra, CM	0.8±0.01	1.1±0.01	1.4±0.01	1.7±0.02	1.9±0.02	1.94±0.01
	Ketac N-100, GC	1.8±0.01	2.2±0.02	2.6±0.02	3.0±0.02	4.0±0.02	5.9±0.02
Middle stability	Filtek Ultimate, NC	3.0±0.01	0.7±0.02	1.1±0.01	1.3±0.02	1.6±0.01	1.9±0.02
	Dyract Extra, CM	0.8±0.01	1.1±0.02	1.8±0.01	2.1±0.01	2.4±0.01	2.7±0.02
	Ketac N-100, GC	1.9±0.01	2.2±0.02	2.5±0.01	3.6±0.02	4.8±0.03	6.5±0.04

In the table. The permeability indices are given (unit of measure is μA).This is due to the fact that CM contains fluorides, which have a total remineralizing effect on dental tissues, leading to an overall improvement in their structural and functional state. These data are consistent with the results of electron probe analysis. For both groups, a significant change in the indicators of regional permeability was recorded in the period up to 2 years. For different materials, these indicators differ.

So, for GC Ketac N-100 over 2 years they changed 3.0 times ($p \leq 0.05$), for CM - also 3 times $p \leq 0.05$, and for NC, on the contrary, they not only did not increase, but even became 0.5 times lower ($p \leq 0.05$). The quality of the seals presented from the GC material is the lowest, since this material has unsatisfactory indicators of the marginal fit, starting from the term of six months (Table 3).For patients from group 2, the best preservation of fillings and the minimum values of marginal fit were established with the preliminary use of ozone for disinfection of the oral cavity. For 95% of cases during ozonation, the safety of fillings was observed for at least 2 years. On the contrary, in the absence of ozonation in 22% of cases, an edge seal depressurization was observed. For group 1, a 1.4-fold improvement in the marginal fit of the fillings was obtained, provided that ozonation was present ($p \leq 0.05$).

Patients from group 2 in terms of aesthetic sensations and overall assessment preferred NC, while patients in group 1 - CM. Based on the foregoing, we have proposed the following algorithm for the selection of materials in the treatment of cervical caries. Low resistance - CM choice, with mandatory ozonation and doctor examinations every 5 months. The average level of resistance to caries is the choice of NC, less often - CM, the optional presence of ozonation, medical supervision - once every six months.

Discussion

By themselves, the features of the anatomical structure of the cervical region indicate an increased risk of caries here. Thus, the cuticle promotes the adherence of proteins and glycoproteins, which can lead to the formation of pellicles [16]. At the same time, with proper hygiene - brushing your teeth, the pellicle, and with it the colonies of microorganisms, including pathogenic microflora, disappears [17]. The pellicle is able to easily recover; its growth will eventually lead to the formation of the so-called bacterial plaque [18]. This is one of the key factors for the occurrence of cervical localization caries, since when teething, as is known, the cuticle is erased on the chewing surface, but its conservation on the cervical and lateral surfaces [19].In cervical localization, the thinnest layer of enamel, besides permeated by lamellas. These lamellas are surrounded by funnels that form furrows together. Furrows, in turn, surround the entire cervical region [20]. The enamel surface is permeable, since there are holes in the area of each lamella that ensure enamel trophy [21]. This makes enamel in the cervical region very permeable to microorganisms. Through the openings, microorganisms can spread deep into the enamel [22]. The third cause of cervical caries is damage to the squamous epithelium [23]. This type of epithelium is located next to the neck of the tooth and contains glycogen, which is known to be a nutrient medium for microflora [24].In addition to the technology used for the ozonation of the cavity in our cavity, there are other technologies, for example, irradiation of the cavity with a diode laser, before direct filling [25, 26]. This technology seems promising to us, but, in the conditions of developing countries, it is ineffective, since not every clinic can afford expensive laser equipment.

At the same time, ozonation is a fairly simple procedure in technology and cost. Before the tooth undergoes cervical caries, a rather long stage of opposition of the organ (and, therefore, the whole organism) to the effects of carious changes is possible [27, 28]. At the same time, areas with increased indicators of tissue hardness, as well as hardness, stability and mineralization may form in the dental tissue [13, 15]. These foci are able to withstand the demineralization of the tooth for some time.

In intact teeth, defects of type 1 are determined, and defects of type 2 are determined in teeth with a wedge-shaped defect. Teeth with cervical caries usually show the lowest enamel strength values [29, 30]. This indicates the danger of cervical caries, since it starts processes more full-scale and harmful in terms of consequences for the human body. Through microcracks from deeper layers of enamel, they can enter surface micronutrients, which somewhat inhibits the demineralization process [31]. The presence of deep microcracks should also be considered an important criterion for assessing the condition of teeth.

Conclusions

When filling NC and CM in the intermediate layer between dentin and material, the structure is homogeneous. The hard tissues of the tooth are enriched due to the contained fluorides. Scanning microscopy data

confirmed the opening of the dentinal tubules. The first group of patients (low resistance to caries) improved 1.4 times the performance of the marginal fit of the fillings, provided that ozonation was present ($p \leq 0.05$). For the second group, the safety of fillings was established for 2 years in 95% of cases, but subject to the presence of ozonation.

References

1. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med., 6(7): e1000097.
2. Sauro S, Pires PM, Moura MEM, Makeeva I, Foschi F, Giovarruscio M, Faus-Matoses V, Faus-Llácer V, Neves AA (2019) Effects of ions-releasing restorative materials on the dentine bonding longevity of modern universal adhesives after load-cycle and prolonged artificial saliva aging. Materials, 12(5): 722.
3. Opdam NJ, van de Sande FH, Bronkhorst E, Cenci MS, Bottenberg P, Pallesen U, Gaengler P, Lindberg A, Huysmans MCDNJM, van Dijkenet JW (2014) Longevity of posterior composite restorations: a systematic review and meta-analysis. J. Dent Res., 93(10): 943-949.
4. De Olivera Carrilho MR (2017) Root Caries: From Prevalence to Therapy. Karger Medical and Scientific Publishers.
5. Rolland SL, McCabe JF, Imazato S, Walls AW (2011) A randomised trial comparing the antibacterial effects of dentine primers against bacteria in natural root caries. Caries Res., 45(6): 574-580.
6. Santos MJ, Ari N, Steele S, Costella J, Banting D (2014) Retention of tooth-colored restorations in non-carious cervical lesions-a systematic review. Clin Oral Investig., 18(5): 1369-1381.
7. Schwendicke F, Göstemeyer G, Blunck U, Paris S, Hsu LY, Tu YK (2016) Directly Placed Restorative Materials: Review and Network Meta-analysis. J. Dent Res., 95(6): 613-622.
8. Schwendicke F, Göstemeyer G (2017) Cost-effectiveness of root caries preventive treatments. J. Dent., 56: 58-64.
9. Srinivasan M, Schimmel M, Riesen M, Ilgner A, Wicht MJ, Warncke M, Ellwood RP, Nitschke I, Müller F, Noack MJ (2014) High-fluoride toothpaste: a multicenter randomized controlled trial in adults. Community Dent Oral Epidemiol., 42(4): 333–340.
10. Van Strijp G, van Loveren C (2018) No Removal and Inactivation of Carious Tissue: Non-Restorative Cavity Control. Monogr. Oral Sci., 27: 124-136.
11. Walsh T, Oliveira-Neto JM, Moore D (2015) Chlorhexidine treatment for the prevention of dental caries in children and adolescents. Cochrane Database Syst. Rev., (4): CD008457.
12. Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeroncic A (2019) Fluoride toothpastes of different concentrations for preventing dental caries. Cochrane Database Syst. Rev., 3: CD007868.
13. Hu DY, Yin W, Li X, Feng Y, Zhang YP, Cummins D, Mateo LR, Ellwood RP (2013) A clinical investigation of the efficacy of a dentifrice containing 1.5% arginine and 1450 ppm fluoride, as sodium monofluorophosphate in a calcium base, on primary root caries. J. Clin Dent., 24 Spec no a: A23-31.
14. Sevbitov AV, Brago AS, Enina YuI, Dorofeev AE, Mironov SN (2018) Experience in the application of hybrid ceramic restorations in the cervical region. Asian Journal of Pharmaceutics, 12(S3): 1106-1109.
15. Hu JY, Chen XC, Li YQ, Smales RJ, Yip KH (2005) Radiation-induced root surface caries restored with glass-ionomer cement placed in conventional and ART cavity preparations: results at two years. Aust. Dent J., 50(3): 186-190.
16. Baca P, Clavero J, Baca AP, González-Rodríguez MP, Bravo M, Valderrama MJ (2009) Effect of chlorhexidine-thymol varnish on root caries in a geriatric population: a randomized double-blind clinical trial. J. Dent., 37(9): 679-685.
17. Baysan A, Lynch E (2007) Clinical reversal of root caries using ozone: 6-month results. Am J Dent., 20(4): 203-208.
18. Cruz Gonzalez AC, Marín Zuluaga DJ (2016) Clinical outcome of root caries restorations using ART and rotary

techniques in institutionalized elders. Braz. Oral. Res., 30(1): 30.

19. Da Mata C, Allen PF, McKenna G, Cronin M, O'Mahony D, Woods N (2015) Two-year survival of ART restorations placed in elderly patients: A randomised controlled clinical trial. J. Dent., 43(4): 405-411.
20. De Moor RJ, Stassen IG, Van't Veldt Y, Torbeyns D, Hommez GM (2011) Two-year clinical performance of glass ionomer and resin composite restorations in xerostomic head- and neck irradiated cancer patients. Clin Oral Investig., 15(1): 31-38.
21. Ekstrand KR, Poulsen JE, Hede B, Twetman S, Qvist V, Ellwood RP (2013) A randomized clinical trial of the anti-caries efficacy of 5,000 compared to 1,450 ppm fluoridated toothpaste on root caries lesions in elderly disabled nursing home residents. Caries Res., 47(5): 391-398.
22. Fure S, Lingström P (2009) Evaluation of different fluoride treatments of initial root carious lesions in vivo. Oral Health Prev Dent., 7(2): 147-154.
23. Gilboa I, Cardash HS, Baharav H, Demko CA, Teich ST (2012) A longitudinal study of the survival of interproximal root caries lesions restored with glass ionomer cement via a minimally invasive approach. Gen Dent., 60(4): e224-30.
24. Göstemeyer G, da Mata C, McKenna G, Schwendicke F (2019) Atraumatic vs conventional restorative treatment for root caries lesions in older patients: Meta- and trial sequential analysis. Gerodontology, 36(3): 285-293.
25. Gruythuysen RJ, van Strijp AJ (2018) Preventive dentistry 9. Non-Restorative Cavity Treatment: advanced insight or controversial? Ned Tijdschr Tandheelkd., 125(1): 33-41.
26. Gruythuysen RJ (2010) Non-Restorative Cavity Treatment. Managing rather than masking caries activity. Ned Tijdschr Tandheelkd., 117(3): 173-180.
27. Hansen NV, Nyvad B (2017) Non-operative control of cavitated approximal caries lesions in primary molars: a prospective evaluation of cases. J. Oral. Rehabil., 44(7): 537-544.
28. Hayes M, Brady P, Burke FM, Allen PF (2016) Failure rates of class V restorations in the management of root caries in adults - a systematic review. Gerodontology, 33(3): 299-307.
29. Li R, Lo EC, Liu BY, Wong MC, Chu CH (2016) Randomized clinical trial on arresting dental root caries through silver diammine fluoride applications in community-dwelling elders. J Dent., 51: 15-20.
30. Lo EC, Luo Y, Tan HP, Dyson JE, Corbet EF (2006) ART and conventional root restorations in elders after 12 months. J. Dent Res., 85(10): 929–932.
31. Mijan M, de Amorim RG, Leal SC, Mulder J, Oliveira L, Creugers NH, Frencken JE (2014) The 3.5-year survival rates of primary molars treated according to three treatment protocols: a controlled clinical trial. Clin Oral Investig., 18(4): 1061-1069.
32. Sauro S, Pires PM, Moura MEM, Makeeva I, Foschi F, Giovarruscio M, Faus-Matoses V, Faus-Llácer V, Neves AA (2019) Effects of Ions-Releasing Restorative Materials on the Dentine Bonding Longevity of Modern Universal Adhesives after Load-Cycle and Prolonged Artificial Saliva Aging. Materials, 12(5): 722-1820.

