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Clinical and economic analysis of dental caries prevention using fluorine-containing sealants

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Abstract

Aim. To conduct a clinical and economic analysis of the effectiveness of the program fissure sealing of first permanent molars with fluorine-containing sealants among schoolchildren of 7–8 years old in six cities of the Republic of Tatarstan.

Methods. Between 2007 and 2011, dentists of six cities of the Republic of Tatarstan performed fissure sealing of permanent first molars using a fluorine-containing sealant in 24,394 schoolchildren aged 7–8 years according to the manufacturer's instruction. A clinical assessment of fluorine-containing sealant retention during tooth eruption was carried out annually, the results were submitted to the organizational and methodological office of the Republican Dental Clinic. The analysis of the complex of signs that have a normal distribution and characterize four degrees of sealant retention on the occlusal surfaces of teeth in children from several cities was carried out by using one-way ANOVA (analysis of variance) with the calculation of a p-value and F-test (according to Ronald Fischer). Statistical data processing was performed using the Microsoft Office Excel 2017 software. The economic analysis was performed by using mathematical modelling.

Results. The use of sealants at the age of 7–8 years ensured the complete safety of the sealant in 80% of children; the development of dental caries in 1.7%; complete and partial loss — 14.3%; disturbance of fit without the development of caries — in 4.1% of cases [p=0.0095 (<0.01); f-test 3.09839]. Clinical and economic analysis using a mathematical hypothesis in sealing with a fluorine-containing composite sealant determined the preservation of the conditionally spent funds for the treatment of 80% of healthy teeth for 4 years of the project in the amount of 6,001,177 rubles. Notional saved costs for the treatment of one tooth with a sealant amounted to 23.7 rubles.

Conclusion. Implementation of the program fissure sealing of first permanent molars with fluorine-containing sealants among schoolchildren of 7–8 years old allows a total of 98.3% of healthy teeth to be preserved and notionally saved costs of sealing fissures to be reduced.

Keywords: fluoride, fissure sealing, children 7–8 years old, dental caries, clinical and economic analysis.

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Background. Reforming the Russian health care system, such as in medical and dental care, to socially disadvantaged groups of society attracts special attention.

The high prevalence of dental caries in the Russian Federation remains highly relevant [1, 2]. Its development is caused by the lack of fluoride content in drinking water [1]. The Republic of Tatarstan belongs to the endemic regions in terms of fluoride content. Many studies have investigated the efficiency of prevention and treatment of dental caries with the local use of fluoride [3, 4].

More than 80% of carious lesions in children, especially in the Russian Federation, are localized on the tooth masticatory surface [5]. Fluoridation has more beneficial effects on masticatory surfaces than on anterior teeth, and on proximal surfaces, such in crevices and fissures, with the effective use of fluoride-containing pastes or applications of fluoride solutions [6].

Fissure sealing is a specific method of preventing caries in succedaneous teeth in children. Sealants are synthetic plastics that are applied to the surface of teeth to close fissures, pits, and depressions. The use of gel for etching causes focal transient demineralization of the enamel to dissolve its inorganic phase. The sealant penetrates the formed micropores of up to 100 μm in size and remains on the tooth surface [7].

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According to previous studies, the preventive effect is manifested as a decrease in the growth of caries by 70%–92%. In Russian and international research, various combinations of methods for the prevention of dental caries are considered [7, 8]. Previous studies demonstrate the use of local fluoride-containing agents supplemented by sealing fissures as one of the most significant technological methods to prevent dental caries in children. In clinical practice, complex preparations are used for sealing, including composite sealants-containing fluorides [9].

Researchers suggest using sealants for 4 years after tooth crowning [10]. If fluorides are present in the sealant, they prevent the penetration of cariogenic substrate into the depth of the fissures, which serves as a culture medium for microorganisms. The presence of fluoride in the sealant, in addition to the direct inhibitory effect on bacteria, stimulates the process of enamel remineralization [11].

Prophylaxis is an economically justified, promising, and effective method for maintaining dental health. However, an economic analysis is required to ensure the effective use of health care resources when introducing new treatment technologies and preventive programs [12].

We aimed to study the economic efficiency of the implementation of a preventive program for centralized sealing of the first permanent molars using fluorine-containing sealants in children aged 7–8 years in six cities of the Republic of Tatarstan based on a clinical assessment of the sealant preservation on the masticatory surfaces.

Materials and methods. A project for centralized sealing of teeth fissures was implemented in 2007–2011 within the framework of the Republican target program for the prevention of dental diseases funded by the Territorial Fund of Compulsory Medical Insurance in the Republic of Tatarstan. Preventive measures included sealing the fissures of the first permanent molars in children aged 7–8 years in the period of their eruption, using the UltraSeal XT fluoride-containing composite sealant.

A total of 24,394 schoolchildren from six cities (Zelenodolsk, Almetyevsk, Naberezhnye Chelny, Yelabuga, Chistopol, and Leninogorsk) were examined in 2007–2011.

The sealing technique was performed in four stages according to the manufacturer's algorithm as follows:

– At stages 1 and 3, the tooth surface was thoroughly cleaned and dried twice (before and after etching) with a stream of water and air.

– At stage 2, the area of fissures of the first permanent molars was treated with 35%–37% phosphoric acid gel for acid etching of enamel for 15–20 s.

– At stage 4, the sealant was applied inside the fissures of the teeth.

The material hardens under the influence of polymerization light.

Clinical assessment of the sealing of fissures was performed annually during the centralized debridement of the oral cavity in schools according to the sealant preservation degree on the masticatory surface of the teeth. The results of the examinations were entered into the children's outpatient medical records, and the reports were submitted to the organizational and methodological office of the Republican dental clinic.

According to the methodological recommendations of P.A. Leus, the number of teeth covered with sealant and the condition of the sealant were assessed according to four criteria, a complete preservation of the sealant, complete and partial loss, disorder of marginal adhesion, and the development of caries. The analysis of the complex of features characterizing the four degrees of preservation of the sealant on the masticatory surfaces of teeth in children from several cities was performed using one-way analysis of variance ANOVA with the determination of the *p*-value and fkp (according to Ronald Fischer). To study the significance of the differences, the conditions of normal distribution were met when comparing unrelated sets of quantitative indicators that were influenced by the sealing factor. The processing of statistical data was performed using the Microsoft Office Excel 2017 software package. The economic analysis was conducted by the method of mathematical modeling. The calculation of the average annual economic efficiency per tooth treated with the sealant is made according to the following equation:

$$\sum_E = \frac{[\sum_1 - (\sum_2 + \sum_3)]:4}{N_y}$$

where economic efficiency ($\sum_E$) is the difference between the costs of conditional treatment of healthy teeth ($\sum_1$) and the costs of the project ($\sum_2 + \sum_3$), divided by 4 years and the number of all sealed teeth (N_y).

$\sum_1$ implies saved (conditional) costs for caries treatment of healthy sealed teeth:

$$\sum_1 = N_3 \times T_y,$$

where N_3 is the number of healthy teeth; T_t is the price of treating medium caries with a chemical curing filling (prices in 2020).

$\sum_2$ is the cost of sealing the fissures of all teeth:

$$\sum_2 = N_s \times T_s,$$

where N_s is the number of teeth covered with sealant; T_s is the sealing price (prices in 2020).

Table 1. Summary of data on the results of sealing the fissures of the first permanent molars in children aged 7–8 years old in six cities of the Republic of Tatarstan in 2007–2011

City	Number of children	Number of teeth	Completely intact		Complete and partial loss		Fitting failure		Development of caries	
			%	number of teeth	%	number of teeth	%	number of teeth	%	number of teeth
Almetyevsk	6,716	13,432	82.7	11,108	8.9	1195	6.4	860	2	269
Zelenodolsk	1,584	3411	71	2,422	23.5	801	0	0	5.5	188
Naberezhnye Chelny	9,498	27,915	81.6	22,779	15.3	4271	2.4	670	0.7	195
Yelabuga	1,752	4176	65.5	2,735	28.2	1178	3.3	138	3	125
Chistopol	4,682	13,824	80.5	11,128	10.7	1480	6.8	940	2	276
Leninogorsk	162	484	74.4	360	21.7	105	1.9	9	2	10
Total	24,394	63,242	79.9	50 532	14.3	9,030	4.1	2617	1.7	1063

$\sum_3$ implies the costs for dental treatment with the development of caries:

$$\sum_3 = N_c \times T_t,$$

where N_c is the number of teeth with the development of caries; T_t is the cost of treating medium caries with a chemical curing filling (prices in 2020).

Results. A summarized data on the assessment of the sealant safety in the cities of Almetyevsk, Zelenodolsk, Naberezhnye Chelny, Yelabuga, Chistopol, and Leninogorsk are presented in Table 1.

ANOVA for the significance of differences with a univariate effect of sealing and a normal distribution of unrelated sets of quantitative signs characterizing the four degrees of the sealant preservation on the masticatory surfaces of teeth in children from several cities, determined the significance of the differences [$p = 0.0095$ (<0.01); fkp = 3.09839]. Clinical and economic efficiency ($\sum_E$) was calculated using the following equation:

For 4 years of the project:

$$\sum_E = \sum_1 - (\sum_2 + \sum_3) = 44{,}602{,}100 - 38{,}600{,}923 = 6{,}001{,}177 \text{ rubles.}$$

In our study, the sealant was completely preserved on 80% of the tooth surfaces using the fluoride composite material, UltraSeal XT, for the prevention of dental caries in children aged 7–8 years.

The average annual efficiency of fluoride sealing is:

6,001,177: 4 = 1,500,294 Russian rubles.

The average annual cost-effectiveness per one tooth treated with sealant is:

1,500,294: 63,242 = 23.7 Russian rubles.

The saved (conditional) costs of caries treatment of healthy sealed teeth are as follows:

$$\sum_1 = N_t \times T_t = 50{,}532 \times 882.65 = 44{,}602{,}070 \text{ Russian rubles,}$$

where N_t is the number of healthy teeth; T_t is the price of treatment of medium caries with a chemical curing filling (prices in 2020).

Fissure sealing costs for all teeth:

$$\sum_2 = N_s \times T_s = 63{,}242 \times 594.9 = 37{,}622{,}666 \text{ Russian rubles,}$$

where N_s is the number of teeth covered with sealant; T_s is sealing cost (prices in 2020).

The cost of dental treatment with the development of caries:

$$\sum_3 = N_c \times T_t = 1063 \times 882.65 = 938{,}257 \text{ Russian rubles,}$$

where N_c is the number of teeth with the development of caries.

Discussion. Many children develop dental caries at the age when they start to require an intake of a certain amount of fluoride. In 2018, in an international study by W.J. Yan et al., when evaluating the clinical effect of fissure sealing used in the treatment of early enamel caries in children, the use of fluorine-containing substances (resin) as a fissure sealant can improve the sealant integrity and prevent the progression of enamel caries effectively compared with a conventional fissure sealant [13].

Temporary teeth need to be sealed in case of a risk of caries. In the study by N.V. Shakovets (2018), dental treatment was performed in 125 children aged 12–36 months with caries of deciduous teeth (cfr > 0[1]) in three randomized groups. In the group where the therapeutic sealing of temporary molars with glass ionomer cement was performed, the risk of caries progression decreased 3.6 times over 3 years in chalky fissures and 20 times in pig-

[1] cfr — the number of carious, filled, and removed deciduous teeth.

mented fissures (odds ratio 19.95) compared with calcium-phosphate-containing gel for 3 years [14].

The decay of deciduous teeth in children did not cause concern for either specialists or parents and was viewed as a temporal problem that did not require preventive measures and treatment. However, studies have begun to appear in the literature reporting an increase in the prevalence of dental disease in young children. L.P. Kiselnikova et al. (2019) conducted a clinical and laboratory examination using fissure sealing of 468 intact first and second temporary molars, which were at the eruption stage in 61 children aged 11 months to 4 years. It was revealed that after 12 months of using glass ionomer cement as a seal in teething temporary molars in young children, the risk of fissure caries is reduced by 95.26%, and enamel maturation in teeth that have lost the sealant is accelerated by 33.54% [6].

In addition, the results of a study by T.N. Terekhova et al. (2020), which included 253 children aged 6–7 years, revealed that the developed scheme of preventive measures with fissure sealing of the first succedaneous molars has high anti-carious efficiency. The study was performed for 24 months with preventive measures to prevent the development of caries on the occlusal surface in 100% of cases [5].

There are few economic analyses of dental prevention programs, which complicate the assessment of their cost-effectiveness. Current data reveal that the number of economic evaluations in dentistry is growing [15]. The results of studies in 2014 indicate the advantage of school preventive programs using fissure sealing, especially in high-risk children, and these methods reduce the cost of caries treatment. The average annual economic benefit per one filled tooth was 6.29 US dollars [16].

The effectiveness of preventive dental programs, including the activities to prevent dental caries, occurs over a long period. Therefore, prediction methods that consider long-term results are used to assess the achievement of benefits and make a decision. However, such models depend on the quality of data used [17].

Our study provides a clinical and economic assessment of dental caries prevention programs based on the results of a 4-year project for centralized sealing of the first permanent molars of children aged 7–8 years in six cities of the Republic of Tatarstan. On average, one child has 2.6 teeth sealed due to different tooth crowning times. The complete safety of the sealant was established in 80% of cases, and the development of caries was recorded on the teeth of a relatively small number of children (1.7%). We classified teeth with complete and partial loss of the sealant and those with adhesion problems without the development of caries as preserved healthy (14.3% and 4.1%, respectively). The results of sealing associated with the development of caries in a small number of children are influenced by errors in the sealing technique, a large statistical sample, and long project terms.

The minimum economic effect from sealing fissures for 4 years of project implementation among children aged 7–8 years was 6,001,177 Russian rubles. The statistical sample of organized schoolchildren aged 7–8 years in this study was 22.8% of 106,935 children of this age in the Republic of Tatarstan. The preventive field in medicine is statutorily acknowledged in many countries, including Russia. Therefore, an economic assessment of community-focused dental care programs will help prioritize preventive activities effectively.

CONCLUSION

The implementation of the fluoride sealing program for the fissures of first permanent molars at children aged 7–8 years preserved a total of 98.3% of healthy teeth ($p < 0.01$; fkp = 3.09839) and reduced saved costs of 6,001,177 Russian rubles for 4 years of the project, with the average annual economic efficiency per tooth covered with a sealant of 23.7 Russian rubles.

Author contributions. N.I.Sh. was involved in the development, approval, and organization of activities of the Prevention Program at the regional government level, as well as collection and processing of materials and writing the text; R.Sh.Kh. analyzed the data obtained; V.N.O. performed the literature review and wrote the text.

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Conflict of interest. The authors declare no conflict of interest.

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