

Prevention of Caries in The Precociously Erupted Permanent Teeth by Treatment of Fissures with Erbium Laser Beams and Sealing Them with Sealants

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Abstract

Dental examination was carried out in 840 children aged from 5 to 11 years according to generally accepted indices. Among them 208 (24.8%) had precocious eruption of secondary teeth. Coccal flora (in 58.8%), less often Neisseria (in 13.7%), fungi of the genus Candida (in 11.4%) and lactobacilli (in 10.5%) were discharged from the dental plaque of these teeth. With regular oral hygiene of children, the amount of oral microflora significantly ($P < 0.05$) decreases.

Preparation of deep fissures of precocious erupted permanent teeth with Er: YAG laser beams followed by sealing them with a light-cured composite sealant "X-flow" results in a reduction of caries in 93.4% of children, when using «Fis-Seal» sealant - in 79.7% of children.

Keywords: permanent teeth, molar teeth, time of eruption, caries, prevention, oral hygiene, fissure sealing, erbium laser.

THE ISSUE RELEVANCE

The role of the first permanent molar teeth is extremely important in pediatric dentistry. These teeth, being the "key of dental occlusion", require close attention from an early age. However, programs for the prevention of dental caries of various levels do not take into account the possibility of precocious eruption of permanent teeth, and thus the initial manifestations of dental caries are missed. A direct relationship has been established between the complexity of odontoglyphics of permanent teeth and their caries damage (Bratthal D. et al, 1996) [6].

According to various authors, the first permanent molar teeth sometimes begin to erupt from the age of four behind the second deciduous molar teeth. They create conditions for the normal eruption of teeth and for stimulation the growth of the corresponding jaws (Dummer P.M. et al, 1990) [7].

In recent years, there has been a relative increase in teeth masticatory surface caries. The surfaces of these teeth account for about 6%, and caries develops in them in 60% of cases (Mc. Donald S.P., Sheiham A., 1992) [8]. This is due to the fact that the masticatory surfaces are most sensitive to caries due to the altered morphology of dental plaque on them (Cho B.K. et al, 2001; Lussi A., 1991) [9,10]. The main assembly of microorganisms that cause dental caries is a biofilm, which, under the "stress" influences, can acquire pathogenic properties and be an indicator of the risk of carious disease (Leus PA, 2008) [3]. The softest spot of the tooth, where caries develops more

often, is the fissures of molar teeth (Kiselnikova LP, 2009) [2].

In the literature, there are scanty data on the dynamics of caries in precocious erupted permanent teeth in children. Poor oral hygiene increases the cariogenicity of dental plaque, which predisposes to a more aggressive course of caries (Supiev T.K. et al., 2015) [5].

Consequently, the regular removal of microorganisms contained in the dental plaque effectively prevents damage to the hard tooth tissues, and the additional use of remineralizing preparations ensures the reverse development of caries at an early stage of the disease (Borovskiy E.V., Leontiev V.K., 1991) [1].

The goal of the work is to develop measures for the prevention and treatment of caries in precocious erupted permanent teeth in children using modern technologies.

Research objectives

- 1) Determine the frequency of the precocious erupted permanent teeth in children;
- 2) To reveal the peculiarities of the clinical course of caries of precocious erupted permanent teeth in children;
- 3) To study the microbial composition in deep fissures of precocious erupted permanent teeth in children;
- 4) To develop measures for the prevention and treatment of caries in precocious erupted permanent teeth in children using modern technologies.

MATERIAL AND METHODS

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A dental examination of 840 children of preschool and primary school age (from 5 to 11 years old) of Almaty city was carried out according to the indices described in the literature (Supiev T.K. et al., 2009) [4]. Among them, the precocious eruption of permanent teeth (PEPT) was detected in 208 (24.8%) of the examined children. In these children, the data of external examination, the pattern of swallowing, breathing, speech, chewing, salivation were recorded. The location of the precocious eruption of permanent teeth (PEPT) in the dentition, their color, shape, depth and type of fissures were determined in the mouth. We studied the spread of dental caries (%) and indices of CFE/cf according to the assessment criteria adopted by the WHO. The hygienic index (HI) of the oral cavity was determined. According to the topographic classification the initial, surface, medium and deep caries were distinguished. According to the indications, the generally accepted methods of X-ray examination were carried out (intraoral sighting X-ray, orthopantomography).

The WHO "Case record for dental status assessment" was filled in for each child, the results obtained (data on the child; the state of hygiene of the oral cavity, temporomandibular joint, buccal mucous membrane, hard tissues of teeth, the need for their treatment; as well as the presence of dentofacial anomalies and coexisting diseases) were recorded in them. A total of 208 WHO "Case records for dental status assessment" were filled in for children with early erupted permanent teeth. When filling in individual case records, the information was found out about the course of pregnancy and childbirth, past diseases, character of the neonatal period, the formation

of the body and the development of a child. The parents questionnaire was performed to study the child's mental development. According to the questionnaire, were studied: the age of the parents, profession, the time of teeth eruption and their carious process damage in the parents, the course of pregnancy, number of the child in order of delivery in the family, the time of temporary teeth eruption in a child, their early removal.

The studies to substantiate the regular oral hygiene effect on the development of caries in precocious eruption of permanent teeth (PEPT) were performed in 103 children. Children are divided into two groups: 51 children were engaged in uncontrolled toothbrushing (compared group); 52 children (main group) received the regular treatment-and-prophylactic measures with the inclusion of a new "R.O.C.S." toothpaste for children (Russia).

In 64 children with precocious eruption of permanent teeth (PEPT), deep fissures of the teeth were cleaned in the traditional way and resolved by sealing with «FisSeal» sealant (compared group). For the children of the main group (39 children) the erbium laser beams were applied to treat deep fissures of the precocious eruption of permanent teeth (PEPT), then they were sealed with «FisSeal» sealant.

The laser beams were obtained by a generating semiconductor erbium laser "Opus-20", which had the following parameters: wavelength - 2.940 nm, pulsed, energy / pulse. ~ 300-1000 mJ. Automatic parameter settings allowed to use different modes for each treatment-and-prophylactic intervention, depending on its type and volume, (Fig. 1 a, b, c).

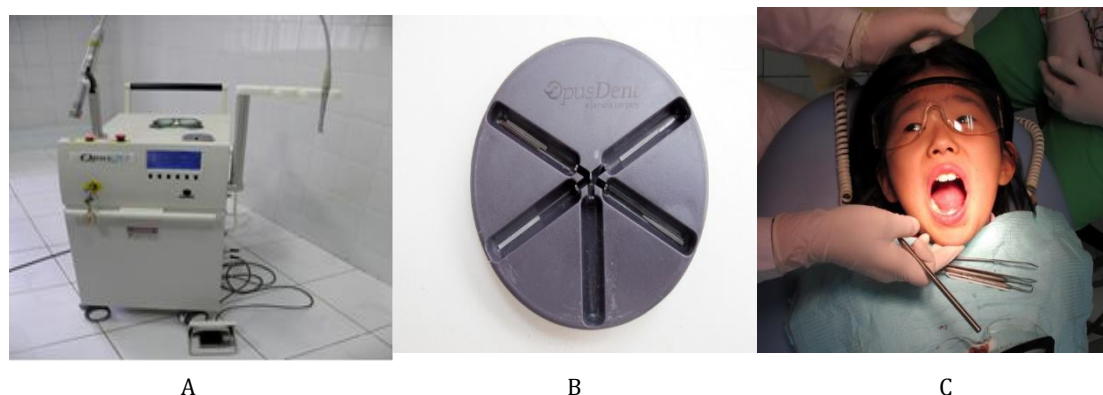


Figure 1. Stages of treatment deep fissures of the precocious eruption of permanent teeth (PEPT) with erbium laser beams: a) the appearance of the highly-energetic laser equipment "Opus-20" program-controlled; b) Sapphire "beams" of the Er: YAG laser; c) Special glasses to protect the patient's eyes from Er: YAG laser beams.

In order to assess the results of the studied methods of prevention and treatment of caries in the precocious eruption of permanent teeth (PEPT), the microflora species composition in dental plaque (biofilm) of 103 children from the first and second study groups was studied twice: before the start of the study and after 12 months of using various prophylactic drugs. Biological

material was obtained from the surface of 17 incisors; 3 canines; 17 premolars and 66 primary and secondary molars.

Thus, the children under study were divided into 4 groups, and the duration of the observation period was 12 months (Table 1).

Table 1. Distribution of children with the precocious eruption of permanent teeth (PEPT) by the methods for treatment-and-prophylactic measures

Groups	Types of treatment-and-prophylactic measures carried out in children with the precocious eruption of permanent teeth (PEPT)	Number of patients	
		N	%
I	Uncontrolled toothbrushing (compared group)	51	24.5
II	Toothbrushing with the new "R.O.C.S." toothpaste for children main group	52	25.0

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III	Sealing of fissures of the precocious eruption of the permanent teeth with «FisSeal» sealant compared group	64	30.8
IV	Sealing of fissures of the precocious eruption of the permanent teeth with «X-flow» sealant after their treatment with erbium laser beams	41	19.7
Total:		208	100.0

RESEARCH RESULTS

In clinical examination of 208 children 353 precociously erupted permanent teeth have been revealed, among which the first molars accounted for 59.6%. Paired eruption of teeth was predominantly noted (93.6%), therefore more often premolars on the upper jaw and molars on the lower jaw. The inconsistency in the pairing of eruption of the first permanent molars was revealed in 13 (6.4%) children.

In clinical and instrumental examination caries of temporary and permanent teeth has been revealed in 103 (54.8%) of 208 children with the precocious eruption of permanent teeth (PEPT). Among them 44% of patients had an aggressive course of dental caries.

In the precocious eruption of permanent teeth (PEPT), carious defects were identified in fissures on the masticatory surfaces of the first permanent molars and first premolars. Clinically, caries in the precocious eruption of permanent teeth (PEPT) was active. In children with a decompensated form of caries, pigmented fissures were detected on the masticatory surface of the first molars, around chalky enamel; when the fissures were opened, the edges of the cavity were sharp, fragile, brittle. The carious cavity reached the enamel-dentin junction. At the bottom of the carious cavity, physiologically unusual predentine was determined. When the fissures were opened in children with a compensated form of caries, the pigmented tissue was determined within the enamel, the edges of the carious cavity were smooth, the bottom was dense, light.

It was found that the mineralization of precociously erupted permanent teeth slowed down within 2-3 years (with the usual eruption time - 1.5-2 years). Precocious eruption of a tooth entailed a reduction in enamelogenesis by 1-1.5 years. An increased risk of caries in the fissure area was associated with their complex geometric shape and morphological structure, which makes the conventional toothbrushing significantly difficult.

In an objective study, thin low-mineralized enamel of the precociously erupted permanent teeth (PEPT) more often underwent the carious process and quickly decayed. In the area of fissures, food debris accumulated, which served as a medium for microorganisms. In children with a decompensated form of the process, pigmented fissures were determined on the chewing surface of the first early erupted molars, around chalky enamel, when the fissures were opened, the edges of the cavity were sharp, fragile, brittle. The carious cavity reached the enamel-dentin junction.

At the bottom of the carious cavity, predentine was determined physiologically. In children with a compensated form of the process when the fissures are opened, the pigmented tissue was within the enamel, the edges of the cavity were smooth, the bottom was dense and light. However, in children with an aggressive course of caries, more often in children of 5-6 years old, caries of medium and deep sizes has already been revealed. According to the parents' words, these children had not previously taken any preventive measures in relation to the precociously erupted permanent teeth (PEPT), which sharply worsened the hygienic state of the oral cavity.

Our clinical observations have shown that precociously erupted teeth in the oral cavity, being still at the stage of structural and functional immaturity (low caries resistance), immediately contact with an aggressive medium (humidity, temperature fluctuations, food products). With insufficient hygienic care of the oral cavity, uncontrolled acceptance of carbohydrates, conditions are created for the formation of plaque on the surface of the teeth and the reproduction of cariogenic bacteria. In turn, low-mineralized, thin, caries-sensitive enamel under the influence of the waste products of microbes is easily destroyed with the formation of a carious cavity.

It should be noted that the use of fluor-containing toothpastes is contraindicated for the population of many cities, especially in childhood, when the development of fluorosis is high. In the Republic of Kazakhstan, such regions include some districts of the Akmola and Almaty regions, etc. Therefore, in order to avoid this, a special children's toothpaste "R.O.C.S." was developed. (World Dental Systems, Switzerland). "R.O.C.S." means Remineralizing Oral Care Systems, which is the essence of the concept of this treatment. As part of the therapeutic and prophylactic toothpaste "R.O.C.S.", there is a complex of minerals, namely a combination of an enzyme, calcium glycerophosphate, magnesium chloride, xylitol. The anti-inflammatory and re-mineralizing potential is enhanced by the action of xylitol.

Xylitol is a natural component belonging to the group of sugar substitutes. It is of natural origin and is made from wood, cotton or coconut shells. It is produced by the human liver and is involved in metabolic processes. According to the mechanism of action, the R.O.C.S. toothpaste Provides long-standing cleanliness and protection from plaque thanks to the enzyme bromelain, which has been successfully used for many years in various fields of medicine and cosmetology. The enzyme bromelain has a proteolytic effect and dissolves plaque by solving the support of bacteria, food debris and pigments, which leads to the fact that they cannot adhere to the surface of the teeth and gums. That's why, "R.O.C.S." has low abrasiveness and, as a result, does not injure the tooth enamel, which is also important for permanent teeth that have erupted precociously. The enzyme has pronounced anti-inflammatory and antiviral properties, having a beneficial effect on the gums. The unique property of xylitol has an anti-carious effect due to the effect on the pathogenic microflora of the oral cavity, the ability to stabilize the pH of saliva, suppress the formation of the dental plaque organic base and stimulate the mineral turnover of enamel. The result of the paste "R.O.C.S." usage is also the disappearance of the fetid breath, caused by the bacterial activity. The effect of the toothpaste is achieved without the use of antibiotics and antiseptics.

We were interested in the influence of various toothpastes on the microflora content on the surface of the precociously erupted permanent teeth (PEPT) in children. To study this issue in two groups of children with the precociously erupted permanent teeth (PEPT) (with uncontrolled toothbrushing and under the supervision of parents, brushing teeth twice a day after eating with

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R.O.C.S. toothpaste). The children have been observed for one year (Table 2).

Table 2. Dynamics of changes in the hygienic state of the oral cavity in children with the precociously erupted permanent teeth who received various therapeutic and prophylactic measures

Studied groups of children	Hygienic Index (HI) Indicators (according to the Fedorov-Volodkina method)					
	In the day of visit to the clinic		after 6 months		after 12 months	
	M	±m	M	±m	M	±m
Uncontrolled toothbrushing	2.2	0.26	1.6	0.27	1.5	0,25 *
Toothbrushing with the new "R.O.C.S." toothpaste	2.3	0.26	1.5	0,27 *	1.3	0,26 *

* The difference in the results is statistically significant compared to the initial data (P <0.05 <0.001).

Before the start of the studies and 12 months after, the children were sampled from the surface of the precociously erupted permanent teeth (PEPT) for

microbiological study of plaque (biofilm), taking into account the technique of sampling the biomaterial. The research results are shown in Table 3.

Table 3. The microflora species composition on the surface of the precociously erupted permanent teeth (PEPT) biofilm in children, depending on the methods of prevention in dynamics

Species of microorganisms	baseline			After 12 months					
	Stock culture (n)	%	CFU/ml	Compared group			Main group		
				Stock culture (n)	%	CFU/ml	Stock culture (n)	%	CFU/ml
Streptococci	92	26.9	2,3.10 ⁴	31	36.6	2,3x10 ⁴	21	33.3	2,0x10 ²
Staphylococci	35	10.2	1,8.10 ⁴	10	11.8	1,8x10 ⁴	8	12.7	1,7x10 ²
Lactobacillus	36	10.5	5,8.10 ³	18	21.2	7,7x10 ³	15	23.8	5,2x10 ³
Neisseria	47	13.8	1,7.10 ³	12	14.1	1,7x10 ⁷	8	12.7	1,2x10 ⁷
Candida	39	11.4	4,4.10 ³	8	9.4	4,4x10 ²	6	9.5	3,6x10 ²
Enterococci	74	21.7	7,7.10 ³	2	2.3	4,8x10 ³	2	3.2	4,4x10 ³
Klebsiella	11	3.2	1,2.10 ²	2	2.3	2,2x10 ²	1	1.6	1,8x10 ²
Veillonella	8	2.3	3,1.10 ³	2	2.3	3,1x10 ⁷	2	3.2	2,4x10 ⁷
Total:	342	100.0	6,3.10 ³	85	100.0	2,2x10 ⁴	63	100.0	1,4x10 ⁴

In the initial state the microbiological studies have established that the plaque on the precociously erupted permanent teeth (PEPT) in children is densely populated (6.3x10⁴ CFU / ml) with various microorganisms (Table 3). Among them, coccal microflora prevailed, which amounted to 4.9x10³ CFU / ml (58.8%).

The second part of the research was devoted to the clinical testing of the method of caries prevention in early erupted permanent teeth by treating deep fissures with erbium laser beams and sealing them with sealants. It has been proven that the use of sealants according to the established practice creates a reliable barrier for the penetration of cariogenic factors into the deep tissues of the tooth, and the active fluoride compounds contained in it contribute to the remineralization of enamel with subsequent reduction of caries in 12 months.

The preparation of the tooth carious cavity with the erbium laser beams was carried out as follows: the laser operates in a pulse mode, sending an average of about 10 pulses every second. Each impulse carried the specific amount of energy. The laser beam, hitting the hard tissues of the tooth, evaporated the finest layers, about 0.003mm. The procedure was absolutely painless for the patient, since there was no strong heating of the tooth and mechanical objects (bur) that irritate the nerve terminals. The tooth carious cavity preparation took place rather quickly.

The dentist is able to control the process, if necessary, immediately interrupting it by releasing the pedal. The erbium laser does not have the same effect as the residual rotation of the turbine after cutting-off the air supply. Easy and complete laser control ensured the highest accuracy and safety. When working with laser technology,

eye protection was used.

The doctor and the patient were wearing eye-protection goggles during work.

When sealing deep fissures, the method of continuous exposure to laser beams with the capacity of 350-500 mJ was used. After the treatment of hard tissues of deep fissures, a flowable «X-flow» sealant containing fluorine was applied.

Clinical observations have shown that the radiation energy of the Er: YAG laser "Opus-20", when sealing deep fissures, prevented the development of possible complications during these interventions. Power adjustment of the apparatus, the possibility of using single repetitive pulses made it possible to select parameters depending on the indications and the volume of intervention.

For this purpose, in 64 children with the precociously erupted permanent teeth (PEPT), a chemical-curing sealant «FisSeal» was used to seal the fissures, which is used as a means of preventing caries in children. According to the instructions, this universal liquid is produced transparent, colored and opaque, which makes it easier to control the condition of the teeth with sealed fissures.

The enamel etching is performed before sealing. In accordance with the instructions, the safety of the sealed fissure is at least five years. «FisSeal» sealant set is stored at a temperature equal to or less than + 4 ° C for 1 year. Before the use, the sealant was kept at room temperature for at least 30 minutes. The adhesion of the sealant to the enamel is 11-12 mPa. The optimum thickness of the applied sealant layer did not exceed 0.5-0.7 mm, so that there was no destruction.

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Table 4. Results of treatment of fissures with erbium laser beams and sealing of the precociously erupted permanent teeth (PEPT) with a sealant in children of different groups

Groups of patients	Total		Sealed teeth fissures		Sealants dropped up within 12 months					
	Children	Teeth	Upper jaw	Lower jaw	Jaws				Total	
					Upper		Lower		N	%
					N	%	N	%		
Application of sealant "FisSeal"	64	148	56	92	8	14.3	22	23.9	30	20.3
Erbium laser beams + sealant "X-flow"	39	106	36	70	2	5.5	7	10.0	7	6.6
Total:	103	254	92	162	10	10.9	29	17.9	37	14.7

The data in Table 4 indicate that preparation of deep fissures of permanent teeth with Er: YAG laser beams for sealing followed by sealing with a composite material is 3.1 times more effective than traditional methods of sealing fissures.

DISCUSSION OF THE RESULTS OBTAINED

Our observations show that oral hygiene in children, regardless of the hygiene products used and the methods of their use, contribute to the improvement of the oral cavity hygienic state to varying degrees.

Our dynamic microbiological studies have revealed a decrease in the level of dental plaque cariogenicity in children of both groups. At the same time, in children of the compared group, the state of oral hygiene has improved after 12 months of uncontrolled tooth brushing and the total number of microorganisms in dental plaque has decreased by 4 times. However, under the influence of the new children's toothpaste "R.O.C.S." the number of microorganisms in the plaque of the precociously erupted permanent teeth (PEPT) decreases more intensively in children from 6.3×10^4 CFU / ml to 1.4×10^4 CFU / ml (in children of the compared group from 6.2×10^4 CFU / ml to 2.2×10^4 CFU / ml). Consequently, it can be traced that in the children of the main group, where the children used the new R.O.C.S. toothpaste, the aggressiveness of dental plaque decreased more effectively. If in the initial state the HI indicators in the patients of the main and compared groups were almost the same, then after 6 months of using the R.O.C.S. toothpaste, the HI of the oral cavity decreased statistically significantly ($P < 0.001$). The indicator was held until the end of observations (1 year). In the patients of the compared group, after 6 months, there was only a tendency to the decrease in the HI indicator, and by the end of one year of observation, this indicator has decreased significantly ($P < 0.05$). These data indicate a significant quantitative reduction of microorganisms after 12 months on the surface of the precociously erupted permanent teeth (PEPT), which indicates the good cleaning ability of the new toothpaste "R.O.C.S."

Thus, the number of microbes on the surface of early erupted permanent teeth in children largely depends on the hygienic state of the oral cavity. All patients should be aware of the importance of hygiene, nutritional regimen, and oral hygiene support should become a generally accepted necessity in the child's daily life. The results of the research have shown that the R.O.C.S. toothpaste has an effective action in thorough mechanical toothbrushing and destroys bacterial plaque, leaving the tooth surface clean. Therefore, children's toothpaste "R.O.C.S." is an effective prophylactic agent against dental caries in case of precocious eruption of permanent teeth (PEPT) and can be recommended for patients for individual prevention of the most common dental diseases.

The erbium laser has proven to be a tool that allows the

dentist to treat hard tissue selectively, painlessly, safely and effectively. Saving the doctor's time, improving the adhesion of filling materials, soundlessness, the absence of microcracks, a non-contact method of application and, the most important, the psychological comfort of the patient are positive properties of the erbium laser.

The advantages of the erbium laser are the hard tooth tissues coverage rate, the absence of a smear layer, non-contactness and the formation of a sterile cavity at the site of the former caries. Preparation of the tooth cavity with laser beams is possible in the immediate neighborhood of the pulp without damaging it, without microcracks on the teeth, selective action on the affected tissues. For this aim the regime and conditions are carefully observed (the constant presence of a water film on the treated tooth surface in order to avoid excess heat generation).

CONCLUSION

In general, after sealing the fissures of 254 precociously erupted permanent teeth (PEPT) by different methods, with consequent filling within 12 months, fillings dropped up in 37 (14.7%) teeth. However, in children where fissure sealing in 148 precociously erupted permanent teeth (PEPT) was performed with a traditional method, fillings dropped up in 30 (20.3%) teeth. In children, where Er: YAG laser beams were used for treatment of hard tissues in 45 teeth with consequent filling only 7 (6.6%) teeth had fillings dropped up. Moreover, fillings from the teeth on the lower jaw dropped up 3 times more often than on the upper jaw.

The application of flexible diffusing fiber technology has contributed to the possibility of bringing up the infrared rays to hard-to-reach areas of the tooth. The advantages of using the energy of the Er: YAG laser include the painlessness of the procedures, which is important in the treatment of teeth in children. Advantages such as the absence of the need to use antiseptic solutions for drug treatment of the tooth cavity, improved adhesion of filling materials due to the absence of a "smear" layer, the absence of cracks on the enamel of the tooth, and other advantages of Er: YAG play an important role in the prevention and treatment of caries in the case of precocious eruption of permanent teeth in children.

Dynamic observation for one year revealed a high clinical efficiency of Er: YAG laser energy use in combination with the sealing of deep fissures with the «X-flow» sealant, which resulted in a reduction of caries in 93.4% of the children observed, than sealing deep fissures with the «FisSeal» only (79.7%).

FINDINGS

1. Among children of preschool and primary school age in the city of Almaty, precocious eruption of permanent teeth was revealed in 24.8% of the examined. Children with precociously erupted permanent teeth need dental treatment and prophylactic measures 3-4 times a year;

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2. It was found that the coccal flora (58.8%), as well as Neisseria (13.7%), fungi of the genus Candida (11.4%) and lactobacilli (10.5%) are most often released from the plaque (biofilm) of the precociously erupted permanent teeth (PEPT). With regular oral hygiene of children using the R.O.C.S. toothpaste the amount of oral microflora definitely ($P < 0.05$) decreases from 6.3×10^4 CFU / ml to 1.4×10^4 CFU / ml (in the compared group - from 6.2×10^4 CFU / ml to 2.2×10^4 CFU / ml).
3. The use of a chemical-curing «FisSeal» sealant for sealing the fissures of the precociously erupted permanent teeth (PEPT) gives a positive result in 79.7% of the precociously erupted permanent teeth treated.
4. The use of the Er: YAG laser energy generated by the semiconductor erbium laser "Opus-20" for the preparation of deep fissures of the the precociously erupted permanent teeth (PEPT) with their subsequent sealing with the composite light-cured sealant «X-flow» gives the reduction of caries in 93.4% of children (in the compared group - 79.7%).

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