FLUORINE: PROS AND CONS

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The ability of fluorine to prevent caries was discovered in the middle of the past century. But there are still active debates about the appropriateness of its use in dentistry.

Fluorine plays a great role in the prevention of dental diseases. Most dentists consider fluorides as the most effective means of decreasing of risk of caries. But is it true? We can notice that fluoride-containing toothpastes have been prevailing during the last decade (up to 95%). But has it lead to decrease of caries prevalence? Fluorination of water was performed in some areas of Moscow and Saint-Petersburg and resulted in significantly less prevalence of caries in children, but this effect was not noticed in adults. According to epidemiologic studies, in the regions where water is saturated enough by fluorine (0.5 – 1 mg/l), the indices of caries are lower, but only in children.

We asked Yuriy Andreevich Fyodorov, who has been studying effective means of prevention of dental diseases for many years, to tell us about the role of fluorine in the activity of human body.

Fluorine in the biosphere and its role in the activity of human organism

Fluorine and its compounds are spread wide in the biosphere, including atmosphere, water, plants, soil and vital organisms. (Russian scientists, first of all, V.I.Vernadskiy and his colleagues, were pioneers of study of biosphere and science of biogeochemistry).

An atom of Fluorine has quite compact and dense structure: its atomic radius is 0.64. At the same time the atomic radius of Iodine (the nearest element in the Mendeleev table) is 1.33. The ionic radius of Fluorine is also minimal, which helps this element to spread between other atoms very quickly. It is characterized as the most reactive (chemically responsive) haloid. This is supported by the maximal affinity with electrons and by high potential ability of ionization. Fluorine does not exist in the nature in free form, but it forms compounds with most elements; fluorine forces out other halogens (Iodine, Bromine, Chlorine) from metallic compounds and replaces them. [1, 2].

Hence, even after a short description of fluorine as a chemical element, we can conclude, that it is characterized not by chance as the most reactive, the most electronegative, the most aggressive, destructive and stable element, with possible unpredictable and original reactions. Fluorine is a very potent oxidant. On the one hand, it forms insoluble and poor soluble compounds with many metals. On the other hand, compounds of fluorine (fluorides) with sodium, potassium, silver, aluminium and some other elements dissolve very well. [1–6].

The physiological role of fluorine in the human body has been being studied for a long time. Fluorine can be found in almost any tissue, but its quantity is not even. There are some amounts of fluorine in all tissues, more in bones, less in ectodermic tissues, where metabolic processes are quite weak. Internal organs contain minimal amount of fluorine.

The amount of fluorine in a human body varies. It depends on its level in drinking water, soil, plants.

Figure 1 Fluorine is one of the most potent oxidants and fluoridizing agents. Thanks to high energy of the element-fluorine link and low energy of F2 dissociation, many reactions of fluoridation of simple substances are irreversible. They are accompanied by release of big amount of heat and by formation of fluoride compounds with highest levels of oxidation. All chemical elements, excluding Helium, Neon and Argon, form stable fluorides.

The main sources of fluorine for a human are food and water. They contain about 75 – 90% of fluorine which falls into the digestive tract; 1 – 5% of which are absorbed by the oral mucosa. The amount of fluorine entering the body such way depends on the time of retaining of its source in the oral cavity. The longer it stays in the mouth, the more fluorine penetrates oral mucosa. Some other factors also play their roles. After entering the digestive tract, fluorine is absorbed predominantly in small intestine, and goes to the blood. The main uneatable sources of fluorine are dental and hygiene means, industrial pollutants in the atmosphere, pesticides, as well as some pharmaceutical and consumer goods.
Fluorine excretion takes place mostly with urine (60–90%), and the rest (including normal) is excreted with faeces and sweat. [4, 7–11]

**Fluorine and its use in dentistry**

In the middle of the past century fluorine was found to have antacaries properties. An optimistic view, related to possible perspective of prevention of caries, appeared immediately. A short time after there appeared staunch defenders of fluoroprophylaxis, as well as its active opponents. Here we are not going to discuss role and importance of natural sources of fluorine – drinking water and food. This issue has been studied widely, but most studies are related to optimal concentrations of fluorine in drinking water and its antacaries activity, as well as possibility of fluorosis (in case of exceeding physiological norm of fluorine intake) [5, 9, 10, 12–14].

Fluorination of drinking water up to optimal concentration of fluorine to provide antacaries effect has been actively discussed till today. The use of fluorine for prevention of dental caries is generally accepted as the most effective and available in different preventive programs. But nevertheless, according to different data, only 200–300 million people in the world drink artificially fluorinated water.

This is connected, most of all, with the view of population and medics on fluorine usage. In some countries, fluorination of drinking water is performed only in one or two cities (in England, Switzerland and other countries), because population looks negatively on such measures. For example, questioning in one of Canadian cities showed that only 47% of population supported the idea of fluorination, 17% opposed it, and 36% found difficulties in answering the question. [15, 16]. The opinions differ significantly in many countries, including Russia. It is interesting that **defenders of fluorine prophylaxis never prevail**. This program has been being conducted in Sankt-Petersburg for 25 years already, and during all these years we faced negative relation to it. There are many protests from parents, who often are chemists and biologists.

**Is this fear righteous? May be, fluorine really has negative effects?**

The presence of fluorine in drinking water and, consequently, in food, in optimal concentration (0.7–1.2 mg/l [7]) is undoubtedly beneficial and promotes processes of mineralization, which for some level prevents dental caries. This is particularly noticeable during the periods of development, eruption and mineralization of second teeth in children and adolescents, at the age of 5–16 y.o. (period of maturing of teeth and skeleton). During this time carbonates in dental tissues are gradually replaced by such mineral components as calcium, phosphate and other macro- and microelements [17–19].

At the same time, excess of fluorides in drinking water leads to development of fluorosis of teeth and skeleton, as well as to other unfavorable events and consequences for the organism. For example, some data show that drinking of water with more than 1.5 mg/l of fluorine leads to increased risk of cervical hip fracture. There is some evidence that excess of fluoride inhibits immune and endocrine systems, increases possibility of some malignant diseases, has negative influence to fetal development, etc. [20–41].

In the very beginning of this, far from full, list of works, there is a publication in the 1928-year issue of the Ontology and Dentistry, where an experiment with white rats is described. Administration of high enough doses (5 mg/l) of sodium fluoride led to disastrous changes in teeth, slowing of growth of bones and cartilages. Clear signs of chronic intoxication were noticed (weight and appetite loss, etc.).

To be honest, we should mention significant inconsistency in publications of defenders and opponents of fluoroprophylaxis. Probably, it is worthwhile to present comparative evaluation of positive and negative or doubtful effects of fluorine.

**Comparative evaluation of the effects of fluorides**

Naturally, data shown in the table are not comprehensive; they can be extended or changed, depending on new scientific and practical results of studies.

When discussing or analyzing methods of endogenous prophylaxis of dental caries (fluorination of water, milk, salt, administration of pills with fluorides of calcium-phosphate compounds, microelements, other bioactive substances), their effectiveness and influence on human body, we should remember that so-called local measures of prevention of caries (varnishes, rinses, gels, dentifrices, etc.) are, for some level, not particularly local. [36].

High absorptive ability of oral mucosa, possibility and probability of swallowing of rinse or dentifrice, including active components, is considered by many authors as convincing and real mechanism of general influence, which is more effective than in case of entering of preventive substances by the digestive tract (Orbit Express, 2003, №14–16).
See below for a table based on literary data and results of proper investigations

<table>
<thead>
<tr>
<th>Positive sides of fluoroprophylaxis</th>
<th>Negative or doubtful sides of fluoroprophylaxis</th>
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<tbody>
<tr>
<td>1. Possible decrease of dental caries intensity.</td>
<td>1. Possible negative influence on the organism, including endocrine, cardiovascular, central nervous systems, digestive tract, and, particularly, skeleton, even if the dose is insignificantly higher than physiological.</td>
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<td>2. Use of fluorine is simple and available (fluorination of water, milk, salt, usage of varnishes, rinses, toothpastes, etc.).</td>
<td>2. Fluorine intake by the organism is difficult to control, especially in case of different ways of fluoroprophylaxis.</td>
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<td>3. Decrease of annual growth of caries in children and adolescents is good enough (20 – 60%) (depending on the chosen method).</td>
<td>3. Effective prevention of caries by means of fluorine is possible only in younger people (about 20% of population); it is not effective in other 80%. Usage of fluorides may be unfavorable for people older than 40 – 45 y.o.</td>
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<td>4. Possibility of coverage of big populations.</td>
<td>4. If fluorides are used alone, without other components (Ca, P, Mg), decrease of caries growth does not exceed 30-35%.</td>
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<td>5. Active participation in the processes of mineralization and remineralization of enamel and dentine by retaining phosphates, calcium and other macro- and microelements in hard dental tissues as a kind of activator or catalyst.</td>
<td>5. It is difficult to forecast possible allergic or other abnormal reaction, especially in case of water fluorination</td>
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<tr>
<td>6. Possibility of administration in different forms: orally (with water, milk, salt, pills) or locally (in toothpastes, gels, rinses etc.).</td>
<td>6. It can be dangerous to use fluoride-containing toothpastes, rinses, chewing gums and other forms in the regions where drinking water contains big amounts of fluoride.</td>
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<td>7. Big experience of usage of fluorides let us look for optimal ways of prophylaxis.</td>
<td>7. Lack of knowledge about individual factors of fluorosis development</td>
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We can make some general conclusions on the basis of analysis of literary data and our studies.

1. Administration of fluorides in prophylactic (physiological) doses has no prominent negative effect and leads to decrease in dental caries growth. But if these doses are exceeded, even minimally, regardless of the way of administration, it can lead to fluorosis of teeth and bones, and negatively influence endocrine, nervous, reproductive, cardiovascular systems. Thus, intake of fluorides should be strongly dosed and controlled.

2. The function of fluorine is to organize process of mineralization by means of retention of phosphate, calcium, magnesium and other macro- and microelements in hard dental tissues. The excess of fluorine disrupts processes of mineral metabolism and is unfavorable both in children and in adults (especially in older people).

3. If the concentration of fluorine in drinking water is normal or high, administration of fluorine products can lead to excessive intake of fluorine (including oral hygiene means). Effective and safe products, developed on the basis of fundamental studies, can be a good alternative for preventive measures; these products showed decrease of caries growth in 2–3 times. The optimal compound to provide physiological mineralization is calcium glycerophosphate, which releases ions of calcium and phosphate under the influence of specific enzymes (phosphatases). This compound provides entry of minerals 16–18 as fast as do inorganic compounds of calcium and phosphate [17, 42–46]. The availability of alternative treatment gives a choice for creation and realization of dental preventive programs, with taking into account geochemical peculiarities of a region, ecological and social conditions.

4. It is important to consider, that process of mineralization is more effective, if a means of prophylaxis is at one time a source of fluorine, calcium and phosphate. For example, calcium glycerophosphate in combination with fluorides, vitamins and other bioactive substances has significantly stronger anticaries effect [47–51].

5. We should also take into consideration minimal mineralizing action of fluorides in people older than 18 y.o. In this case it is reasonable to use product (toothpastes in particular), which contain calcium-phosphate compounds and bioactive substances with minimal amount of fluoride (0,03 – 0,05%), i.e. to chose more reasonable, effective and safe method of prevention.

6. When evaluating sources of fluorine in ratio, we should consider not only tap water but one from the bottled drinks. For example, our investigation of commonly used drinks Coca-cola and Pepsi-cola shown that concentration of fluoride was higher than 4 mg/l; at the same time, almost all samples of bottled table water did not contain enough amount of fluorine [52].

7. Preventive measures should be complex and aimed to the whole body and teeth in particular. This is the principle of prophylaxis, which gives the best result.

8. One of the most important components of preventive programs in dentistry is to motivate population in necessity of professional monitoring and following all the administrations. It should be pointed out, that dentists not always can motivate their patients effectively. A probable reason may be connected with lack of information.

If we can realize all these useful recommendations, we will reach high results in dental prophylaxis.

![Figure 2](image-url) The main sources of fluorine are water and food, from which up to 75 – 90% of fluorine enters the digestive tract. Excess of fluorine in drinking water leads to fluorosis of teeth and skeleton and other unfavorable effects and consequences for the organism.
5. Габович Р.Д., Овруцкий Г.Д. Фтор в стоматологии и гинекологии. – Казань, 1989. – 512 с.
6. Вернадский В.И. Химический состав живого вещества в связи с химией земной коры. – М., 1922. – 48 с.
17. Федоров Ю.А. Профилактика заболеваний зубов и полости рта. – Л., 1979. – 144 с.
25. Патрикеев В.К. Материалы к клинике и патогенезу эндемического флюороза // Стоматология. 1959, №5, – с. 9–12.
27. Гущин С.К. Влияние фтористого натрия на йодистый баланс у кроликов в остром опыте // Гигиена и санитария. 1960. Т. 19, №6, С. 70–75.
42. Федоров Ю.А. Влияние фосфорно-кальциевых и фтористых соединений на экспериментальный кариес зубов у белых крыс // Докл. АН СССР. 1961. Т. 37, №6, с. 1481–1484.
47. Федоров Ю.А. Изучение местного действия глицерофосфата кальция и фтористого натрия на экспериментальный кариес зубов у белых крыс // Докл. АН СССР. 1965. Т. 161, №1. с. 244–248.
50. Дрожжина В.А. Естественные биологически активные вещества в профилактике и лечении заболеваний зубов и пародонта: Автореферат диссертации на соискание степени доктора медицинских наук. – СПб, 1995. 33 с.
51. Федоров Ю.А. Гигиена полости рта для всех.– СПб., 2003. 112 с.
52. [Б.а.] Фториды в том, что мы пьем // Профилактика Today. 2006, сентябрь.