DENTISTRY

PREVALENCE OF MALOCCLUSIONS UNDER CONDITIONS OF PROLONGED INTRODUCTION OF SYSTEMIC FLUORIDES IN VARIABLE CONCENTRATIONS: LITERATURE REVIEW

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ABSTRACT

The pathogenesis of malocclusion, which are common among the population of all countries, is well represented in the professional literature. The occurrence of bite problems is associated with genetic and various environmental factors. Among the latter, fluorides which affect the prevalence of some dental diseases are of particular interest. However, there are few publications reflecting the frequency of malocclusion among the population in the regions with different levels of fluoride in drinking water. This problem seems to be significant in the context of the increasing impact of fluorine compounds on human health, including dental health.

The aim of the study. *To analyze the literature on the frequency of malocclusion among the population living in conditions of variable fluoride content in drinking water. A manual search of domestic and foreign literature was performed in the search databases PubMed, Medline and Google Scholar. From the initial list of publications, eighteen articles that met the inclusion criteria for the study were selected for analysis. We revealed significant variability of the research results. Some authors note a higher prevalence of malocclusions among the population under conditions of increased fluoride intake, others note a lower one, and still others did not reveal any differences between the values obtained in both samples. Most of the assessed publications did not methodologically meet modern international standards, and therefore were of little evidence.*

The literature data do not provide grounds for an unambiguous assessment of fluorine compounds as an environmental factor that indirectly affects the process of occlusion formation in humans and animals.

The review did not allow to make a definitive conclusion on the possible impact of systemic fluorides on the prevalence and pattern of malocclusion in humans and animals. It requires the implementation of studies that comply with the principles of evidence-based medicine.

Key words: *malocclusion, fluorides, drinking water, teeth, bone, teething, tooth size*

Received: 30.03.2022
Accepted: 13.01.2023
Published: 02.03.2023

For citation: Belyaev V.V., Gavrilova O.A., Belyaev I.V., Myalo O.A., El-Aydi M.A. Prevalence of malocclusions under conditions of prolonged introduction of systemic fluorides in variable concentrations: Literature review. *Acta biomedica scientifica*. 2023; 8(1): 158-169. doi: 10.29413/ABS.2023-8.1.18

РАСПРОСТРАНЁННОСТЬ ЗУБОЧЕЛЮСТНЫХ АНОМАЛИЙ В УСЛОВИЯХ ПРОДОЛЖИТЕЛЬНОГО ПОСТУПЛЕНИЯ ВАРИАТИВНЫХ КОНЦЕНТРАЦИЙ СИСТЕМНЫХ ФТОРИДОВ: ОБЗОР ЛИТЕРАТУРЫ

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РЕЗЮМЕ

Патогенез нарушений прикуса, широко распространённых среди населения всех стран, хорошо представлен в специальной литературе. Возникновение зубочелюстных аномалий связывают с генетическими и разнообразными факторами окружающей среды. Среди последних особый интерес представляют фториды, оказывающие влияние на распространённость ряда стоматологических заболеваний. Однако публикации, отражающие частоту малокклюзий среди населения в регионах с различным уровнем фторидов в питьевой воде, малочисленны. Данная проблема представляется значимой в условиях возрастающего воздействия соединений фтора на здоровье, в том числе стоматологическое, человека.

***Целью исследования** явился анализ литературы о частоте нарушений окклюзии у населения, проживающего в условиях вариативного содержания фторидов в питьевой воде. Выполнен ручной поиск отечественной и зарубежной литературы в поисковых базах PubMed, Medline, Google Scholar. Из первоначального списка публикаций для анализа выбраны 18 статей, отвечающих критериям включения в исследование.*

Выявлена значительная вариативность результатов исследований. Одни авторы отмечают более высокую распространённость зубочелюстных аномалий среди населения в условиях повышенного поступления фторидов, другие – меньшую, третьи не выявили различий между значениями, полученными в обеих выборках. Большинство оцениваемых публикаций методологически не соответствовали современным международным стандартам, в связи с чем были малодоказательными.

Данные литературы не дают оснований для однозначной оценки соединений фтора в качестве средового фактора, опосредованно влияющего на процесс формирования окклюзии у человека и животных.

Обзор не позволил сделать окончательного заключения о вероятном влиянии системных фторидов на распространённость и структуру малокклюзии у человека и животных. Требуется выполнение исследований, соответствующих принципам доказательной медицины.

***Ключевые слова:** зубочелюстные аномалии, фториды, питьевая вода, зубы, кость, прорезывание зубов, размеры зубов*

Статья поступила: 30.03.2022
Статья принята: 13.01.2023
Статья опубликована: 02.03.2023

Для цитирования: Беляев В.В., Гаврилова О.А., Беляев И.В., Мяло О.А., Эль-Айди М.А. Распространённость зубочелюстных аномалий в условиях продолжительного поступления вариативных концентраций системных фторидов: обзор литературы. *Acta biomedica scientifica*. 2023; 8(1): 158-169. doi: 10.29413/ABS.2023-8.1.18

RELEVANCE

Bite problems, or malocclusions, are one of the most common pathologies of the dental system in the world's child population [1–3]. Researchers pay special attention to the etiology of occlusion anomalies, since their prevention is impossible without identifying and eliminating the causes of the development of occlusal disorders [4]. In the majority of cases, bite problems are associated with uncontrollable (genetic predictors) and controllable (environmental factors) preconditions. Several authors point to a genetic background, the elimination of which is not currently possible, as the predominant precondition for the formation of occlusal pathology [5]. However, most specialists consider malocclusion to be unlikely as a result of a single cause, as the process of bite formation is long, with the probable influence of many negative factors that have a potentiating effect [6]. The identification and elimination of the latter is therefore of particular importance.

Despite a significant number of studies devoted to the etiology of malocclusion, there is not enough work on some factors that may play a role in the development of bite problems. Fluoride is widely distributed in the environment (water, soil, food, dental products, etc.). Sources of fluorides are varied, but most of them (up to 70 %) are ingested with drinking water. The trace element has a narrow "therapeutic corridor", and therefore its deficiency or excess can lead to changes in teeth and bones. Prolonged and excessive ingestion of fluoride compounds is accompanied by abnormalities in the functioning of various human and animal systems and organs, especially bone tissue. Fluorides affect bone remodeling processes, increase osteoblast proliferation and inhibit osteoclast function, and are an inducer of increased bone volume and mineralization [7]. Systemic fluorides, which have proven effects at the oral organs and tissues [8, 9], would be a potential cause of the formation of occlusal disorders among humans and animals [10]. Presumably prolonged exposure by fluoride compounds can act as a symbiotic factor (predisposing or preventing) for malocclusion.

In recent decades, as a result of the expansion of the range of sources of fluoride intake into the human body, there has been an increasing impact on the health of the population living in conditions of not only elevated but also optimal and even reduced levels of this trace element in drinking water. Currently, the main supplier of facultative fluoride to the child's body is fluoride-containing toothpastes, the systematic use of which during the formation of dental tissues in children from hydro fluorosis zones leads to the development or aggravation of the clinic of dental fluorosis [11–13]. The increasing prevalence of malocclusion and fluorosis among the child population in most regions of the world suggests the possible involvement of fluorides in the formation of bite problems, which justifies a review of previous studies in this area.

THE AIM OF THE STUDY

Analysis of the professional literature about the incidence of occlusion disorders in humans and animals under conditions of prolonged intake of systemic fluorides of different concentrations.

MATERIALS AND METHODS

A manual search of national and foreign literature was conducted in PubMed, Medline and Google Scholar search databases using keywords and their combinations: fluorides, drinking water, malocclusion, teeth, bone, teething, teeth size. Publication inclusion criteria for the review: taking into account the small number of thematic publications, both full-text and annotated articles containing at least data on the incoming fluoride levels and the prevalence/structure of bite problems were selected. Exclusion criteria: publications presented only with metadata (no annotation); publications that do not have information about fluorides. Only 18 of the 156 articles initially selected for review were published in Russia (13), Europe (1) and Asia (4) between 1959 and 2021. In view of the overall number and level of publications, we considered it possible to provide a detailed summary of the study in the section entitled "Study results".

STUDY RESULTS

The analysis of scientific articles confirmed the influence of fluorides on the body and health, including dental, of humans and animals [14, 15]. The effect of optimal and increased fluoride concentrations over the clinical and statistical picture of caries to temporary and permanent teeth has been proved. The prevalence and intensity of dental caries among children and adolescents from areas with low fluoride levels in drinking water were significantly higher than among peers living in hydro fluorosis areas [16, 17]. In a situation of excessive and prolonged intake, mainly from drinking water, of fluoride in the child's body during the period of dental formation, the probability of developing fluorosis increases [18]. There are studies indicating multidirectional, but in most cases negative effects of elevated fluoride doses on periodontal tissues [19, 20]. Studies on humans and animals have shown the negative impact of excess fluoride concentrations on bone cells and their remodeling processes, leading to chronic skeletal fluorosis, accompanied by bone lesions in the form of osteosclerosis or osteoporosis, degenerative changes of joints, calcification of ligaments, etc. [21].

The literature on the prevalence of malocclusions among the population in regions with different fluoride levels in drinking water is few and varied.

The first group of authors notes a lower prevalence of malocclusion among residents of areas with optimal and elevated fluoride levels in drinking water compared with the population from regions with low fluoride levels.

R.K. Aliyeva (1999) conducted an epidemiological survey of Azerbaijani children born and permanently residing in two regions that differ in the level of fluorides in water: in Baku (less than 0.5 ppm) and Absheron (more

than 1.5 ppm). The prevalence of bite problems in the child groups was 41 and 35 %, respectively, which allowed the author to consider the lack of fluoride in water as a risk factor for malocclusions among children [22].

An examination of children and adolescents 3–19 years old, born and permanently residing in Karaganda (Kazakhstan), using the unified methodology of the Central Research Institute of Dentistry and Maxillofacial Surgery (CRIDMS) revealed an inverse relationship between fluorosis and malocclusions. In a sample of children with a high prevalence of dental fluorosis, the incidence of dental caries and occlusion anomalies was significantly lower [23–25].

Y.L. Obraztsov (1994) studied the frequency of bite problems in samples of children with a higher and lower prevalence of dental fluorosis and showed that occlusal disorders were more frequently diagnosed among schoolchildren in the first group. In addition, the author points out that the content of fluoride affects not only the prevalence of occlusion disorders, but also the severity of their clinical manifestations [26]. Yu.L. Obraztsov and T.N. Yushmanova (2000), when studying trends in the incidence of malocclusions among children in the Arkhangelsk region over the past 15–20 years, revealed a significant increase (by 24 %) in their prevalence. The least frequent cases of DAA were observed among children living in an area with optimally elevated levels of fluoride in drinking water [27].

An analysis of dental morbidity among children in the Krasnodar region has revealed that low fluoride levels in natural drinking water sources contribute to the development of dental anomalies in children [28].

S.B.R. Chandra and colleagues examined 15-year-old Indian schoolchildren from regions with below optimal (less than 0.7 ppm), optimal (0.7–1.2 ppm) and above optimal (over 1.2 ppm) fluoride levels in drinking water using the dental aesthetic index (DAI). The prevalence of malocclusions was significantly higher among the pupils in the first group. The average DAI score in the first group of pupils was statistically significantly higher than in groups two and three, i. e. it decreased with increasing fluoride concentration in drinking water. Severe and very severe bite abnormalities were more common in the first group than in adolescents in the other groups [29].

However, **the second group of authors** found a higher prevalence of occlusal abnormalities among children and adolescents who consumed water with a higher fluoride content.

A large-scale study to assess the dental morbidity of the population of different climatic and geographical regions of Russia has confirmed that the prevalence of dental abnormalities was significantly higher among residents of areas with increased fluoride content in water supply sources compared with the residents of areas characterized by deficiency of this micronutrient [30].

Based on a review of the literature that evaluated the risk factors for the development of bite problems among children, the lowest prevalence of anomalies was found in areas with optimal fluoride levels in drinking water, while the highest prevalence was found in areas with high fluoride levels [31].

A study of the dental status among children living in the emission zone of the Tajik aluminium factory and children from pollution-free area showed a higher prevalence of bite problems among children from the first group (39.8 %) compared to their peers from the second group (3.7 %) [32].

The unfavorable geochemical situation in Transbaikalia (elevated fluoride content in drinking water) has led to a high incidence of malocclusion, fluorosis and dental caries. In the structure of bite abnormalities among children under three years old, a prognathic bite combined with an open bite, as well as an open bite, were observed to be statistically significantly more prevalent than in areas with insufficient and optimum fluoride levels in the water. The inconsistent and early eruption of temporary teeth among these children is a risk factor for the formation of malocclusions. In areas of hydro fluorosis, children are 2.2 times more likely to develop dental pathological abnormalities, including the DAA [33–35].

A third group of authors found no or equivocal in their interpretation about the association between the clinical and statistical characteristics of malocclusion among children and adolescents and the level of incoming fluoride.

V.V. Belyaev and colleagues performed a single-stage dental examination among 361 schoolchildren aged 12 and 15 years from Tver, according to the methodology of the World Health Organization (1997), who lived in conditions of optimally elevated fluoride levels in drinking water (1.5–4.5 ppm). A high prevalence of dental fluorosis and dentoalveolar anomalies has been found among the pupils examined. There were no statistically significant differences between the prevalence of bite problems, most DAI components in samples of pupils with and without dental fluorosis of varying severity. An increase in the incidence of anteroposterior ratio deviations of the first permanent molars has been observed in groups of pupils with severe dental fluorosis [36, 37].

Z. Krzoglu et al. surveyed two samples comprising a total of 332 Turkish preschool children (3–6 years) permanently living in regions with elevated (mean 2.16 ppm) and low (0.04 ppm) fluoride levels in drinking water. The socio-economic status of children in both groups was comparable. Other possible risk factors were assessed using questionnaires. There is variability in the frequency of various occlusal abnormalities between the groups. In only half of the cases were the differences between the values obtained statistically significant. An anterior cross-bite appeared to be statistically significantly more common in children in the first group, an anterior open bite and incisor crowding in children in the second group [38].

A. Masztalerz et al. examined a total of 372 children aged 12 in four areas with varying fluoride concentrations in drinking water and air. The severity of pathological occlusion was assessed using the Eismann – Masztalerz method. Optimal concentrations of fluorides in drinking water (0.7–0.9 ppm) have been demonstrated to reduce the severity of abnormalities apart from crowding of teeth, whereas concentrations above the optimum (4.0–7.0 ppm) as well as fluoride-contaminated air are among the causes of incisor crowding [39].

DISCUSSION

This review of the assessment of the prevalence and severity of pathological occlusion in the population under conditions of different levels of fluoride intake allowed us to identify three main groups of studies characterized by contradictory results.

The findings of the first group about the higher incidence of malocclusions among child populations from regions with low fluoride levels in drinking water seem logical. In such populations, dental caries is more common, and its intensity becomes higher. The probability of developing caries complications in the form of pulp and periodontal inflammation, early extraction of temporary teeth and first permanent molars increases. Generally, the resulting defects cannot be repaired with removable partial dentures or fixed space maintainers, which results in displacement of neighboring teeth and the formation of bite problems [40, 41].

This algorithm for maxillofacial disorders is particularly important in regions with insufficient and low levels of dental care available to children. The model under consideration is not unambiguous in the long term, but it is recognized as relevant for the age at which the majority of malocclusionsand deformities are formed [42].

With multiple caries, especially in conditions of hypophthorosis, the intensity of carious lesions increases not only of the teeth, but also of their surfaces, mainly those in contact [43]. Given the lack of accessibility of pediatric dental care in some regions of the world, multiple carious lesions of the proximal surfaces of teeth in children can lead to a reduction in the mesiodistal dimensions of the crowns, sagittal drift of the affected teeth, shortening of the dental arches and eventually to secondary dental displacement and impaired occlusion [44–46]. Asymmetric mastication, pathological reorientation of the occlusal contacts, often occurring against a background of secondary adentia, can be a trigger for the formation of occlusal disorders, especially in the presence of additional risk factors. In particular, an unilateral mastication could cause an unilateral posterior crossbite, which is a broad asymmetrical bite anomaly characterized by an inverse relationship between the upper and lower vestibular dental cusps in the area of the molars and premolars on the same side of the dental arch. Patients with a unilateral posterior crossbite have altered mastication cycles and the masseter muscle is less active on the side of the crossbite than on the contralateral side [47].

The aforementioned findings demonstrate the benefits of administering optimal doses of fluoride compounds from natural or fluoridated drinking water sources to children, associated with the control of both dental caries and associated dental diseases and conditions, including bite disorders [7]. However, there are arguments for controversy regarding this point of view. A number of authors have reasonably observed that studies of the effects of fluorides applied to human and animal oral organs and tissues without having taken into account all possible risk factors can lead to misinterpretations of the results obtained [48, 49]. An underestimation of a significant variable, such as the socio-economic status of a family or individual, contributes to a misinterpretation of the information obtained in the study. As a rule, individuals with lower status are typically associated with inadequate dental compliance (do not regularly visit the dentist for the prevention and treatment of dental diseases, do not follow the generally accepted recommendations for individual oral hygiene, etc.), do not have the opportunity to eat rationally, etc., and are more likely to have untreated dental caries and its complications. Among such individuals, even in conditions of optimal and increased fluoride intake, available level of dental care, untreated dental caries and its complications, cases of tooth extraction without subsequent dental prosthetics are more often revealed [50, 51].

The studies underline the fact that the range of human and animal sources of fluoride has expanded in recent decades, significantly altering the epidemiology of fluoride-associated dental diseases directly or indirectly. The current literature data suggest that the algorithm of the variables "dental caries – dental defects – maxillofacial anomalies" that has been formed in the past decades remains relevant, and the order of "systemic fluorides – dental caries – dental defects – maxillofacial anomalies" now needs further study and possibly reinterpretation.

The second group of studies analyzed by us indicates a higher incidence of bite problems among the population consuming water with optimal or elevated fluoride levels, which can also be explained.

Chronic fluoride intoxication is accompanied by abnormalities in the functioning of cardiorespiratory, neuroendocrine, musculoskeletal, dental and other human systems and organs. The positive and negative effects of fluoride on bone tissue have been described in the literature [52]. Fluoride has been demonstrated to increase the proliferation of osteoblasts and inhibit osteoclast function, and is an inducer of increased bone volume and mineralization [53]. A significant number of factors affecting bone metabolism and the complexity as well as diversity of the manifestations of fluoride effects in bones, including jaw bones, which go beyond just changes in bone density, have been pointed out [54]. The results of studies examining the rate of tooth movement under the influence of orthodontic appliances in humans and animals under prolonged systemic ingestion of a variety of fluoride concentrations have confirmed these findings [55].

Orthodontic treatment is associated with the movement of teeth through the reconstruction of the alveolar bone. The pressure exerted on the crown of the tooth is transmitted through the root to the ligamentous apparatus of the periodontium and the alveolar bone. In the tissues of the jaw bone, compression zones arise, where the alveolar bone is resorbed, and stretching zones, where the bone is formed. It has been shown that different concentrations of endogenous fluorides can have several different effects on orthodontic tooth movement and in combination with mechanical forces and associated factors can have synergistic, preservative or inhibitory effects [56]. Intensive systemic use of sodium fluoride in order to prevent caries during orthodontic treatment can slow down the rate of tooth move-

ment and prolong the period of active treatment [57]. Animal studies have shown that fluorides, especially with long-term exposure, reduce the rate of tooth movement while undergoing simulated orthodontic treatment [58]. Along with medications (bisphosphonates, corticosteroids, estrogens, aspirin, diclofenac, ibuprofen, indomethacin, etc.), endogenous fluorides can be classified as factors that slow down tooth movement during orthodontic treatment [59]. However, a number of authors do not share this opinion. During orthodontic treatment of young people from cities with very low (0.05 ppm) and elevated (2 ppm) fluoride levels in drinking water, a higher rate of tooth movement was detected among the second group of patients [60]. Y.U. Yangyang et al. (2016) among adolescents without fluorosis and with dental fluorosis of varying severity showed significantly greater tooth movement distance and less alveolar bone resorption area in the group of patients with fluorosis at every treatment stage. The authors conclude that fluorides play a positive role in bone remodeling during orthodontic treatment [55]. However, simulated orthodontic treatment of animals confirmed a statistically significant increase in the number of osteoblasts on the extension side and a decrease in their number on the compression side, but showed no difference in the dynamics of tooth movement under conditions of insufficient and excessive systemic fluoride intake [61]. The variability in the results of these studies may be associated with limitations in their design, as bone remodeling is a multifaceted and complex process, influenced by a number of different factors, including genetics and environmental conditions [62].

Tooth eruption is a genetically determined process, but is influenced by a number of general and local factors: racial, ethnic, gender, socio–economic, geographical and others [63]. Animal studies have confirmed a delay in the eruption of mandibular molars in experimental rats that constantly consumed fluoridated water [64], which allows us to consider fluoride as a potential environmental factor not only prolonging the timing of tooth emergence in the mouth, but also indirectly negatively influencing the formation of occlusion.

The morphology of the teeth, especially the mesiodistal and buccolingual dimensions, has a significant influence on their position in the dentition and the development of occlusion in the temporary and permanent bites. In turn, tooth size is influenced by both genetics and numerous environmental factors [65]. Among the latter are fluorides, the prolonged and excessive intake of which, mainly with drinking water, is capable of affecting the size and morphology of teeth in humans and laboratory animals. This effect has been noted in numerous studies and has been confirmed by the work of the Turkish authors, who in a study of dental parameters among children and adolescents with fluorosis revealed smaller crown sizes in the permanent upper incisors, second premolars and first molars. The sizes of temporary teeth with and without fluorosis did not differ [66]. Similar findings were observed by their compatriots, who revealed that the mesio-distal dimensions of teeth were larger among adolescents without fluorosis and with a normal bite than among their peers with this pathology. However, in most cases there were no statistically significant differences between the indicators obtained in the compared groups of patients [67]. The significantly smaller diameter and height of the cusps of fluorotic permanent teeth is indicated by C.J.M. Ten et al. [68]. Y.B. Aswini and colleagues, analysing the literature findings about the influence of fluoride on dental morphology, pointed to less pronounced (small and wide) fissures in molars among patients who consumed water or products with elevated fluoride concentrations [69]. Ameloblasts are known to be highly sensitive to internal and external influences. Indonesian scientists have demonstrated a negative effect of high doses of fluoride in drinking water against enamel development in rats as a result of apoptosis in ameloblasts and an increase in intercellular space, resulting in the formation of thinner enamel and smaller teeth [70].

The analysis of scientific studies carried out at different times in different countries, including different age and social groups of the population, as well as animals, did not allow an unequivocal assessment of the impact of systemic fluorides on bone tissue, teething processes and their macromorphology. However, obtaining the most objective information possible about the issue is of great importance in clinical dental practice. The morphological characteristics of the teeth are the most important factors influencing the positioning of the teeth in the dental rows [71], whose abnormal size correspondence leads to anomalies of occlusion in different directions, changes in function [72].

The literature review allowed us to note two main points. First, despite hundreds of studies conducted over the past decades to assess the impact of systemic fluorides on human dental health, only eighteen publications were accepted for analysis in accordance with the selection criteria for this study, demonstrating the relevance of the problem in question. Second, the methodological basis of the majority of studies published more than a decade ago varies considerably and is characterized by the variety of assessment tools used by the authors (different classifications, indices), racial and age samples of the surveyed population, levels of professional competence of experts, which served as one of the reasons for the inconsistency of the results obtained. The use of unified methodological approaches in similar case studies is known to enable comparison of results at national and international levels and to increase the reliability of the results [73]. Even significant quantitative indicators without proper research quality are unable to influence the outcome of the review. Thus, the conclusion of a recent critical review assessing the effect of systemic fluorides against statistical indicators of dental caries, a topic that is very widely and extensively represented in the specialized literature, pointed out the lack of studies that meet the criteria for inclusion in the Cochrane review and the need for further in-depth studies [74].

CONCLUSION

A review of the literature demonstrated the ambiguity of data on the frequency and structure of malocclusions un-

der conditions of long-term variable intake of systemic fluoride compounds, i. e. its possible role in the formation of human and animal occlusion. Although a summary of a review based on an analysis of publications in the Google, Rutgers Library, PubMed, and Medline databases did not identify fluoride as a risk factor for bite problems [75], the findings of this study justify further research in this area, with qualitative studies based on evidence-based methodologies.

Conflict of interest

The authors of this article declare the absence of a conflict of interest.

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