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Effects of vaping on the tactile sensitivity of the oral mucosa

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ABSTRACT

BACKGROUND: The rapid spread of vaping, which directly impacts the oral mucosa, highlights the importance of evaluating its effect on tactile sensitivity in electronic cigarette users.

AIM: To clarify the characteristics of tactile sensitivity of the oral mucosa in electronic cigarette users.

MATERIALS AND METHODS: The study included 80 participants (mean age 23.5±0.2 years), divided into two groups: the observation group (40 regular electronic cigarette users) and the comparison group (40 never-smokers). Each participant underwent an objective dental examination and an assessment of tactile discrimination sensitivity at four alveolar zone points (upper and lower jaws, left and right) using Weber's compass. Statistical analysis included the calculation of mean values, standard errors, and significance testing using Student's *t*-test.

RESULTS: Physical oral examination revealed that the prevalence of gingivitis among electronic cigarette users was six times higher, whereas dental calculus was 7.5 times more frequently relative to the comparison group. The DMF index was 57.1% higher in the vaping group, whereas the Green–Vermillion hygiene index was 109.1% higher. Assessment of tactile discrimination sensitivity revealed that its threshold was significantly higher in electronic cigarette users than in non-smokers. On the upper jaw, sensitivity thresholds in vapers were 1.5 times higher (left: 7.71±0.30 mm, right: 7.63±0.27 mm) compared to non-smokers (left: 5.15±0.06 mm, right: 5.10±0.08 mm). On the lower jaw, the difference was even more pronounced: 2.3 times higher on the left side (13.33±0.49 mm in vapers and 5.69±0.05 mm in non-smokers) and 2.5 times higher on the right side (12.85±0.55 mm in vapers and 5.18±0.05 mm in non-smokers).

CONCLUSION: The use of electronic cigarettes is accompanied by a significant deterioration in the hygienic condition of the oral mucosa and a reduction in its tactile sensitivity, which may lead to the latent progression of inflammatory and degenerative processes in the oral and dentoalveolar system.

Keywords: vaping; electronic cigarettes; oral mucosa; tactile sensitivity.

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Влияние вейпинга на тактильную чувствительность слизистой оболочки полости рта

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АННОТАЦИЯ

Обоснование. Стремительное распространение вейпинга, оказывающего непосредственное действие на слизистую оболочку полости рта, придаёт актуальность оценке её тактильной чувствительности у пользователей электронных сигарет.

Цель. Уточнить особенности тактильной чувствительности слизистой оболочки полости рта у пользователей электронных сигарет.

Материалы и методы. В исследовании приняли участие 80 человек (средний возраст 23,5±0,2 года), из которых было сформировано две группы: наблюдения (40 человек, регулярно использующих электронные сигареты) и сравнения (40 никогда не куривших). У каждого обследуемого оценивали объективные стоматологические показатели и тактильную дискриминационную чувствительность в четырёх точках альвеолярной зоны (на верхней и нижней челюстях, слева и справа) с помощью циркуля Вебера. Статистическая обработка включала вычисление средних величин, их ошибок, статистической значимости различий по *t*-критерию Стьюдента.

Результаты. Объективное исследование полости рта выявило, что частота гингивита у потребителей электронных сигарет в 6 раз выше, зубного камня — в 7,5 раза выше, чем в группе сравнения. Индекс КПУ у курящих на 57,1% выше, чем у некурящих, а индекс гигиены по Грину–Вермиллиону — на 109,1%. При оценке тактильной дискриминационной чувствительности установлено, что её порог у курящих электронные сигареты на верхней челюсти с обеих сторон был в 1,5 раза выше (слева 7,71±0,30 мм, справа 7,63±0,27 мм), чем у некурящих (слева 5,15±0,06 мм, справа 5,10±0,08 мм), на нижней челюсти слева — в 2,3 раза (13,33±0,49 мм и 5,69±0,05 мм соответственно), справа — в 2,5 раза (12,85±0,55 мм и 5,18±0,05 мм соответственно).

Заключение. Использование электронных сигарет сопровождается существенным ухудшением гигиенического состояния слизистой оболочки полости рта и вызывает снижение её тактильной чувствительности, что приводит к латентному прогрессированию воспалительных и дистрофических процессов слизистой и зубочелюстного аппарата.

Ключевые слова: вейпинг; электронные сигареты; слизистая оболочка полости рта; тактильная чувствительность.

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电子烟对口腔粘膜触觉敏感性的影响

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摘要

论证。电子烟的迅速普及直接影响口腔粘膜，使评估电子烟使用者的口腔粘膜触觉敏感性具有重要现实意义。

目的。明确电子烟使用者口腔粘膜触觉敏感性的特征。

材料与方法。研究共纳入80名受试者（平均年龄 23.5±0.2 岁），分为两组：观察组（40人，定期使用电子烟）和对照组（40人，从未吸烟）。对所有受试者进行客观的口腔检查，并使用韦伯触觉辨别测试测量上、下颌左右四个牙槽区的触觉辨别敏感性。统计分析包括均值计算、标准误差计算，并使用Student’s t检验 进行组间差异显著性分析。

结果。口腔检查显示，电子烟使用者牙龈炎发生率较对照组高6倍，牙石形成率高7.5倍。龋失补指数（DMF index）较非吸烟者高57.1%，Greene-Vermillion口腔卫生指数高 109.1%。在触觉辨别敏感性测试中发现，电子烟使用者的触觉阈值较非吸烟者显著升高：上颌两侧分别高 1.5 倍（左侧7.71±0.30 mm，对照组5.15±0.06 mm；右侧7.63±0.27 mm，对照组5.10±0.08 mm）；下颌左侧高 2.3 倍（13.33±0.49 mm，对照组 5.69±0.05 mm），右侧高 2.5 倍（12.85±0.55 mm，对照组 5.18±0.05 mm）。

结论。电子烟的使用导致口腔粘膜卫生状况显著恶化，并降低其触觉敏感性，从而引起口腔粘膜及牙颌系统炎症和营养不良性病变的潜在进展。

关键词：电子烟使用；电子烟；口腔粘膜；触觉敏感性。

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BACKGROUND

Vaping commonly refers to the use of electronic cigarettes (e-cigarettes), vaporizers, and similar devices [1]. The global fight against smoking has led to a decrease in tobacco consumption. However, this has been replaced by increased vaping. The most recent statistics show that the number of e-cigarette users increased from approximately 7 million in 2011 to 35 million in 2016 and 55 million in 2021 [2]. In the United States, 10.5% of middle school students and 27.5% of high school students vaped in 2019 [3]. The rapid increase in e-cigarette use, particularly by young adults and adolescents, is due to the casual attitude toward electronic vaping devices and the perception that these devices are fashionable. Moreover, electronic media promotes the idea that this type of smoking is relatively safe [1].

Sales professionals and opinion leaders present e-cigarettes as a safe system with pleasant organoleptic properties [4]. However, e-cigarette liquids contain components such as propylene glycol, glycerin, flavorings, colorings, and additives, including nicotine. Furthermore, the aerosols produced during vaping contain many toxic components, including metal nanoparticles, formaldehyde, diacetyl, acrolein, acetaldehyde, and acetone [5, 6].

Today, most studies evaluating the effects of e-cigarettes on the body focus on respiratory diseases in vapers. The most common combination of symptoms associated with vape-related lung injury is EVALI (e-cigarette and vaping-use associated lung injury) syndrome. Other lung damage in e-cigarette users is possible, including acute respiratory distress syndrome [1]. Previous studies have provided data on functional disorders of the upper and lower gastrointestinal tract in vapers as determined by peripheral electrogastroenterography and pH-impedancemetry [7, 8]. These disorders are manifested by lower quality of life as measured by the specific Gastrointestinal Symptom Rating Scale and the non-specific Short Form-36 questionnaires [9].

Several studies have investigated the influence of e-cigarettes on dental health [10]. In particular, characteristic mucous membrane changes, such as bleeding and structural changes of the gingiva, were observed in the oral cavities of e-cigarette users. Additionally, lower interalveolar septal height and a high incidence of xerostomia were found [4]. There is evidence that e-cigarettes promote periodontitis [11]. A microbiological evaluation of the oral mucosa of vapers has shown that e-cigarette aerosols lead to oral dysbiosis manifested by the inhibition of commensal reproduction and the increased formation of opportunistic microbe biofilms (e.g., *S. mutans*). These conditions allow for the rapid colonization of the mucosa by *Candida albicans*, which may lead to acute candidiasis [12, 13]. Analysis of the oral fluids of e-cigarette users showed a significant increase in rhodanide levels associated with the regular inhalation of hydrocyanic acid metabolites from the inhaled aerosol [14]. This inhalation is accompanied by a decrease in the protective and antibacterial functions of saliva [15].

A detailed understanding of the normal physiology of the oral mucosa and its sensory function requires studying the differences in pain sensitivity to various mechanical influences. This study could be used to solve dental disorders, especially in orthopedic treatment [16]. Previous studies of the tactile sensitivity of the oral mucosa determined the quantitative threshold at various points on both jaws of individuals of different sexes. It was found that there are no sex differences in healthy populations. No significant differences in sensitivity thresholds between the jaws were revealed. Thus, the authors considered this type of sensitivity to be a single type [17]. The evaluation of the pain sensitivity threshold of the oral mucosa in patients with chronic somatic diseases (chronic kidney disease, inflammatory bowel disease, and type 2 diabetes mellitus) showed an increase that persists even when the disease is under control [18]. The data on changes in tactile sensitivity thresholds of the oral mucosa in internal and endocrinological diseases is important for both dental disease treatment and management of underlying chronic diseases. Given the rapid increase in vaping and its direct influence on the oral mucosa, assessing oral tactile sensitivity in e-cigarette users is relevant.

The study aimed to specify the of tactile sensitivity in the oral mucosa of e-cigarette users.

MATERIALS AND METHODS

Study Design

A cross-sectional single-center observational study was conducted.

Eligibility Criteria

The study included volunteers who complied with the study design (e-cigarette users and non-smokers). None of the participants had systemic or severe dental diseases. The exclusion criteria of the study included acute infectious diseases, significant dysfunction of internal organs due to somatic diseases, diabetes mellitus, mental illness, and gestation or lactation.

Study Setting

The study was conducted at the Izhevsk State Medical Academy of the Ministry of Health of the Russian Federation.

Study Duration

All study participants underwent a single dental assessment of status and tactile discrimination sensitivity (TDS) assessment of the oral mucosa.

Intervention

Dental parameters, including the dental formula, the decayed, missing, and filled teeth (DMFT) index, and the

GreenVermillion hygiene index (OHI-S) were evaluated in all participants and appropriate oral care recommendations were provided. Oral mucosa sensitivity was assessed using the TDS threshold at preset points on the alveolar zone of the premolars on both sides.

Main Study Outcome

The TDS threshold was determined on the upper jaw on the side of the hard palate and on the lower jaw on the anterior surface of the alveolar gingiva in the premolar area as these zones have identical oral mucosa structures and pliability [17].

Subgroup Analysis

A total of 80 people (40 males and 40 females) aged 18 to 30 years (mean age: 23.5 ± 0.2 years) participated in the study. The participants were divided into two groups. The observation group included 40 participants (20 males and 20 females) who were regular e-cigarette users. The control group included 40 non-smokers who never smoked (20 males and 20 females).

Outcomes registration

Weber's compass was used to determine the TDS threshold. The compass's legs were placed on the oral mucosa. The minimum distance (mm) at which two touches were distinguished was set when the legs were moved further apart.

Ethics Approval

The study was approved by the local Ethics Committee of the Izhevsk State Medical Academy of the Ministry of Health of the Russian Federation (protocol No. 761 dated September 26, 2023).

Statistical Analysis

Univariate statistical methods were used for statistical analysis in Statistica 6.0 and Microsoft Excel . Parametric methods were used as the data distribution corresponded to a normal distribution (normality was verified using the asymmetry coefficient). The results were presented as the mean ± standard error of the mean (M ± m). Student's *t*-test was used to determine the reliability of quantitative variable differences. Results were considered significant at $p \leqslant 0.05$.

RESULTS

Participants

Seventy-five percent of study participants in the observation group had two to four years of experience with e-cigarettes; whereas the remaining 25% participants had more than four years of experience. Eighty percent of vapers used smoking liquid with a nicotine content of 20 mg/ml; whereas the rest used liquid with a nicotine content of 50 mg/ml or higher. Additionally, 70% of e-cigarette users took 150–500 puffs per day; 20% took less than 150 puffs; and 10% took more than 500 puffs.

An analysis showed that 40% of participants had concerns about gingival bleeding, including 15% of non-smokers and 25% of e-cigarette users. Seventy-five percent of study participants indicated a desire to change the color of their teeth for aesthetic reasons, including 35% of non-smokers and 40% of e-cigarette users.

Primary Results

An objective examination of the oral cavity showed significant differences between groups in terms of oral mucosal condition, degree of caries, and hygiene (see Table 1).

E-cigarette users had a 6-fold higher frequency of gingivitis and a 7.5-fold higher frequency of dental calculus compared to the control group. Smokers had worse DMFT and OHI-S values than non-smokers.

The study of the TDS threshold of the oral mucosa using Weber's compass show demonstratively a significantly lower sensitivity in the observation group (see Table 2).

The study found that the TDS threshold of the oral mucosa on the upper jaw (both right and left) was 1.5-fold higher in e-cigarette users compared to the control group. In the observation group, the value on the lower jaw was 2.3-fold higher on the left and 2.5-fold higher on the right compared to non-smokers.

DISCUSSION

The significant difference in objective assessments of oral cavity condition between smokers and non-smokers is clearly related to the less careful hygiene by e-cigarette users and the influence of inhaled aerosol components on the

Table 1. Objective examination of the oral cavity (M ± m)

Parameters	Observation group (*n*=40)	Control group (*n*=40)	*p*
Frequency of gingivitis, %	30.00±7.25	5.00±3.45	0.003
Frequency of xerostomia, %	2.5±2.4	0	0.301
Frequency of dental calculus, %	37.5±7.7	5.0±3.4	< 0.0001
DMF index	5.5±3.6	3.5±2.9	0.666
GreenVermillion oral hygiene index	2.3±2.3	1.1±1.6	0.667

Table 2. Threshold of tactile discrimination sensitivity of the oral mucos (M±m). mm

Points	Observation group (*n*=40)	Comparison group (*n*=40)	*p*
Left upper jaw	7.71±0.30	5.15±0.06	< 0.0001
Right upper jaw	7.63±0.27	5.10±0.08	< 0.0001
Left lower jaw	13.33±0.49	5.69±0.05	< 0.0001
Right lower jaw	12.85±0.55	5.18±0.05	< 0.0001

oral mucosa and dentoalveolar apparatus. The combination of nicotine and glycerol creates favorable conditions for the deposition of nicotine plaque on teeth and oral mucosa. This plaque is covered by a glycerol film that promotes the multiplication of pathogenic microorganisms, causing rapid progression of dental carious lesions and exacerbating existing inflammatory periodontal diseases [4]. According to previous studies, xerostomia is the most common side effect of e-cigarette use, affecting 2.5% of participants in the observation group [10].

A significant increase in the TDS threshold of the oral mucosa, along with poor oral hygiene and a higher frequency of inflammatory lesions and carious processes, creates a false sense of well-being in e-cigarette users. This contributes to the progression of inflammatory and dystrophic diseases without obvious clinical manifestations, allowing users to postpone dental visits for oral cavity sanitation.

A lower sensitivity of the oral mucosa in chronic kidney, intestinal, and endocrine diseases found by other authors is usually associated with dystrophic and degenerative processes in the nerves that innervate the oral mucosa. These include disorganized myelin and the complete demyelination of some axons, as well as axoplasmic vacuolization. They develop due to metabolic disorders in patients with severe internal diseases [18]. However, no significant differences were found in the degree of decrease in mucosal sensitivity of the upper and lower jaws in cases of somatic diseases. The significant difference in TDS thresholds of the mucosa of the upper and lower jaws in the e-cigarette study group (1.7-fold on both sides) indicates the profound local damaging effect of the inhaled aerosol and systemic effects caused by inhalation. The TDS threshold of the oral mucosa in non-smokers was close to other studies with similar data on the absence of significant differences in tactile sensitivity in the alveolar zone of the upper and lower jaws in the premolar area on both sides [17].

Study Limitations

The study was limited by the young age of the participants and their short history of e-cigarette use. In addition, only the TDS of the oral mucosa was assessed.

CONCLUSION

The study indicated a significant adverse effect of inhaled aerosol on the oral mucosa when using e-cigarettes. E-cigarette users showed a significant increase in TDS threshold in all evaluated zones of the lower and upper jaws compared to non-smokers. E-cigarette users showed a 1.7-fold higher increase in lower jaw TDS compared to upper jaw TDS. The deterioration of oral mucosa sensitivity is accompanied by oligosymptomatic progression of inflammatory and dystrophic diseases of the oral mucosa and dentoalveolar apparatus. This progression is more common in e-cigarette users due to poor oral hygiene and the direct damaging effect of inhaled aerosol components.

Further study of the TDS of the oral mucosa could lead to a better understanding of its sensory function and the influence of various local and general damaging factors that dentists encounter daily.

ADDITIONAL INFORMATION

Author contributions. A.E. Shklyaev — concept and design of the study, writing the text, compiling the list of references, statistical data processing; I.G. Malakhova — writing the text, statistical data processing, editing; V.A. Khamidullina — collection and processing of material. All authors confirm that their authorship meets the international ICMJE criteria (all authors have made a significant contribution to the development of the concept, research and preparation of the article, read and approved the final version before publication).

Ethics approval. The study was approved by the local Ethics Committee of the Izhevsk State Medical Academy of the Ministry of Health of the Russian Federation (Protocol No. 761 dated 09/26/2023).

Patients' consent. Written consent was obtained from all the study participants before the study screening in according to the study protocol approved by the local ethic committee.

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Disclosure of interests. The authors confirm the absence of obvious and potential conflicts of interest related to the publication of this article.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. А.Е. Шкляев — концепция и дизайн исследования, написание текста, составление списка литературы, статистическая обработка данных; И.Г. Малахова — написание текста, статистическая обработка данных, редактирование; В.А. Хамидуллина — сбор и обработка материала. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

Этическая экспертиза. Исследование одобрено локальным этическим комитетом ФГБОУ ВО «Ижевская государственная медицинская академия» Министерства здравоохранения Российской Федерации (протокол № 761 от 26.09.2023).

Информированное согласие на участие в исследовании. Все участники до включения в исследование добровольно подписали форму информированного согласия, утверждённую в составе протокола исследования этическим комитетом.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Раскрытие интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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