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ORAL HEALTH IMPLICATIONS OF ELECTRONIC NICOTINE DELIVERY SYSTEMS: A BIOCHEMICAL, CLINICAL, AND CASE-BASED REVIEW

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Abstract

The increasing popularity of electronic nicotine delivery systems (ENDS), including e-cigarettes and vapes, has raised significant concerns about their impact on oral health. While frequently marketed as safer alternatives to conventional tobacco products, these devices contain nicotine, propylene glycol, vegetable glycerin, and flavoring agents, all of which may exert adverse effects on oral tissues. This review synthesizes current data on the biochemical and clinical alterations observed in users of e-cigarettes. Salivary changes include reduced buffering capacity, increased acidity, oxidative stress, and impaired antimicrobial defense mechanisms, leading to xerostomia, dysbiosis, and heightened susceptibility to caries and periodontal disease. Mucosal manifestations involve cytopathological changes, inflammatory cytokine imbalance, and increased prevalence of oral lesions such as leukoplakia, candidiasis, and stomatitis. Hard tissues are affected through demineralization, hypersensitivity, and esthetic deterioration. A documented clinical case of oral erythema multiforme in a young vape user highlights the potential for severe immunopathological reactions, which improved following cessation of vaping and local therapy. The findings underscore that vaping is not a harmless lifestyle practice but a clinically relevant risk factor for oral pathology. Timely recognition of its effects is essential for preventive strategies, patient education, and appropriate therapeutic interventions.

Keywords: Electronic cigarettes; Vaping; Nicotine delivery systems; Oral health; Saliva; Oral mucosa; Periodontal disease; Caries; Oxidative stress; Erythema multiforme.

Introduction

In recent years, the widespread use of electronic cigarettes and vaping devices has emerged as a significant public health concern. Initially promoted as a safer alternative to traditional tobacco smoking, these devices have gained popularity, particularly among adolescents and young adults. Their accessibility, diverse flavors, aggressive marketing, and perception of reduced harm have contributed to a sharp rise in consumption worldwide.

Although electronic nicotine delivery systems (ENDS) are often positioned as less harmful than combustible cigarettes, accumulating evidence suggests that they are far from risk-free. Vaporized

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aerosols generated during vaping contain nicotine, carbonyl compounds, heavy metals, and ultrafine particles, all of which may adversely affect systemic and oral health. Studies increasingly report associations between vaping and cardiovascular, respiratory, and neurological disturbances, as well as detrimental effects on oral tissues.

The oral cavity, as the primary contact site for inhaled vapor, is particularly vulnerable to the toxic and irritant properties of these aerosols. Reported manifestations include xerostomia, changes in salivary pH, mucosal irritation, periodontal inflammation, and delayed wound healing. Furthermore, exposure to heated propylene glycol, glycerol, and various flavoring chemicals may disrupt the oral microbiome, promote biofilm formation, and increase susceptibility to dental caries and periodontal disease.

Given the rapid spread of vaping, especially among younger populations, a thorough understanding of its impact on oral health is of both clinical and preventive significance. Dentists and maxillofacial specialists increasingly encounter patients who use ENDS, making it essential to recognize early pathological changes and develop effective strategies for counseling, prevention, and management. This study therefore aims to evaluate the specific alterations in the oral cavity associated with electronic cigarette and vape use, providing insights for clinical practice and public health interventions.

Classification of Electronic Nicotine Delivery Systems

To properly assess the potential risks of electronic cigarettes and vape devices for oral and respiratory health, it is first necessary to understand the diversity of these products. Despite variations in design, all of them operate on rechargeable batteries and share the same principle: a liquid is heated and transformed into an inhalable aerosol, commonly perceived by users as “vapor.” This perception has created the widespread belief that vaping is a safer alternative to smoking. Indeed, the absence of combustion prevents the formation of tar and carbon monoxide, but the core active component of most devices remains nicotine, a neurotoxic substance with a strong addictive potential. The wide range of flavorings makes these products especially appealing to young people, increasing the risk of early nicotine dependence.

Modern devices are not uniform. The most common are liquid-based vaporizers, which use solutions of propylene glycol and glycerin, often combined with flavorings and different forms of nicotine. Another group is represented by so-called “heat-not-burn” systems, which do not use liquids but heat processed tobacco to a point where nicotine and aromatic compounds are released without combustion. Some devices, known as mechanical mods, are technically very simple and lack protective electronics. Users manually control heating, which carries risks of overheating and the production of harmful aldehydes. In contrast, more sophisticated “regulated” devices are equipped with microprocessors, allowing control of temperature and voltage and offering protection against overheating or short circuits, though their higher price limits widespread use.

In addition to technical differences, these devices vary in how they are consumed. Disposable e-cigarettes, already charged and filled with liquid, are designed for a limited number of inhalations and usually attract beginners who want to experiment. Reusable devices, on the other hand, can be recharged and refilled, and allow the user to adjust the nicotine concentration and technical

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parameters. Such systems are typically chosen by experienced consumers seeking greater control over their intake.

The growing popularity of vaping has sparked active debate about its safety. Manufacturers highlight the absence of combustion products and present these devices as a less harmful alternative to smoking. However, this argument does not answer the main question: is inhaling vapor truly harmless for the user and those nearby? To address this, it is essential to analyze the chemical composition of the inhaled liquids, since regardless of the model, it is the aerosolized substances that interact directly with the oral cavity, respiratory tract, and ultimately the entire organism.

Composition of E-Cigarette Liquids

Despite the variety of commercial brands and flavor options, the composition of e-cigarette liquids is structurally uniform. Their formulation is based on a small group of key components, each playing a specific role in the formation of the inhaled aerosol.

The backbone of most liquids consists of propylene glycol (PG) and vegetable glycerin (VG). Propylene glycol is a hygroscopic dihydric alcohol widely used in pharmacology as a solvent and carrier for injectable and oral medications. Within vape solutions, it enhances flavor transmission and provides the characteristic “throat hit.” Vegetable glycerin, in contrast, is a viscous trihydroxy compound derived from the hydrolysis of plant oils. It is recognized as safe for use in food and cosmetic products and is primarily responsible for producing dense, voluminous vapor clouds, while also imparting a slightly sweet aftertaste.

Flavorings represent the second important component. These are mixtures of volatile organic compounds, most often food-grade, dissolved in propylene glycol. The vape industry relies on substances that remain stable at elevated temperatures, avoiding oil-based essences or compounds such as diacetyl, which has been associated with bronchiolitis obliterans when inhaled. The broad palette of available flavors significantly increases consumer appeal, particularly among younger populations.

Finally, nicotine remains the central pharmacologically active ingredient. A potent alkaloid, it binds to nicotinic acetylcholine receptors, causing short-term stimulation of the central nervous system while rapidly inducing dependence. In e-liquids, nicotine is present either in freebase form or as nicotine salts, which differ in bioavailability and in their irritant effect on the respiratory tract.

When assessing the safety of these components, it is essential to distinguish between their established safety in oral or dermal use and their behavior when inhaled as an aerosol. Both propylene glycol and glycerin are generally considered low in inhalation toxicity, yet under conditions of overheating they may degrade into harmful byproducts such as formaldehyde and acetaldehyde. Flavorings are safe when ingested but have not always undergone thorough toxicological evaluation regarding their effects on airway epithelium. Nicotine, unlike the other components, is classified as a pharmacologically active substance with a high addictive potential (ICD-10 code F17.2), capable of inducing neurochemical adaptations and long-term tolerance.

Taken together, this composition demonstrates that while e-cigarette liquids are often promoted as benign, their aerosolized form introduces toxicological uncertainties that extend beyond traditional safety assessments based on ingestion.

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Oral Cavity Alterations Associated with E-Cigarette and Vaping Use

The chronic use of e-cigarettes and vaping devices induces complex biochemical and structural changes in the oral cavity, affecting saliva composition, mucosal integrity, periodontal health, and dental hard tissues.

One of the first measurable alterations occurs in the biochemical profile of saliva. Aerosols generated by electronic cigarettes have been shown, through Fourier-transform infrared spectroscopy (FTIR), to increase the concentration of polysaccharides, phenylalanine derivatives, and inorganic phosphates, while simultaneously reducing esterification levels. These shifts reflect impaired enzymatic activity, particularly a reduction in α-amylase function, which is essential for carbohydrate metabolism and local immune defense. Furthermore, oxidative stress markers such as malondialdehyde are elevated, whereas total antioxidant capacity (TAOS, TEAC) declines. Parallel reductions in lysozyme, lactoferrin, and secretory IgA weaken the natural antimicrobial properties of saliva. The increase in lactate dehydrogenase (LDH) activity provides additional evidence of epithelial cell damage within the oral mucosa.

Beyond biochemical disruption, the physicochemical properties of saliva are also compromised. Propylene glycol (PG) and vegetable glycerin (VG), two primary components of vape liquids, exert osmotic effects that lead to dehydration of the mucosa and the development of xerostomia. This reduction in salivary flow decreases buffering capacity, shifts the oral environment toward acidity, and promotes enamel demineralization. Xerostomia also diminishes natural self-cleaning mechanisms, thereby favoring the proliferation of cariogenic bacteria.

At the level of the oral mucosa, significant dysbiosis of the microbiota is observed. Users exhibit increased prevalence of pathogenic anaerobes, including Porphyromonas gingivalis, Fusobacterium nucleatum, and Tannerella forsythia, closely resembling the microbial profile of conventional smokers. This imbalance favors persistent inflammation. Salivary and gingival crevicular fluid analyses further confirm an inflammatory shift, with elevated pro-inflammatory cytokines (IL-1β, IL-6, TNF-α, IFN-γ, GM-CSF) and reduced anti-inflammatory IL-10, indicating a cytokine-driven mechanism of chronic mucosal inflammation.

Cytopathological changes are also well documented. Regular vaping has been associated with nicotine stomatitis, oral candidiasis, leukoplakia, “hairy tongue,” and angular cheilitis. Cytological assays reveal increased micronucleus frequency in epithelial cells, a recognized marker of genotoxic stress induced by inhaled aerosols.

Periodontal tissues are similarly compromised. Clinically, e-cigarette users show higher plaque indices, deeper periodontal probing depths, increased bleeding indices, and measurable clinical attachment loss—changes comparable to those seen in traditional smokers. Mechanistically, nicotine and other aerosol constituents impair vascularization, inhibit fibroblast proliferation, and suppress β1-integrin expression, while simultaneously activating matrix metalloproteinases (MMP-8, MMP-9). These processes drive extracellular matrix degradation, disrupt tissue remodeling, and delay reparative responses. Consequently, regenerative capacity after periodontal therapy, surgery, or implant placement is diminished, largely due to impaired angiogenesis and local immune imbalance.

Finally, hard dental tissues are directly affected. Reduced salivary flow and buffering, together with the presence of sugars and flavoring additives in vape liquids, enhance colonization by

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Streptococcus mutans and other cariogenic organisms, increasing the risk of demineralization and caries. Structural changes in enamel, hypersensitivity, and surface staining are also observed. Persistent pigmented deposits result from the binding of nicotine-like substances and residual flavoring agents, a process facilitated by the adhesive properties of propylene glycol. These changes not only compromise enamel microstructure but also negatively impact dental aesthetics.

Taken together, these findings demonstrate that vaping is far from harmless in its effects on the oral environment. The combined influence of biochemical, microbial, and structural alterations mirrors, and in some cases parallels, the damage observed in traditional tobacco use.

Case Report:

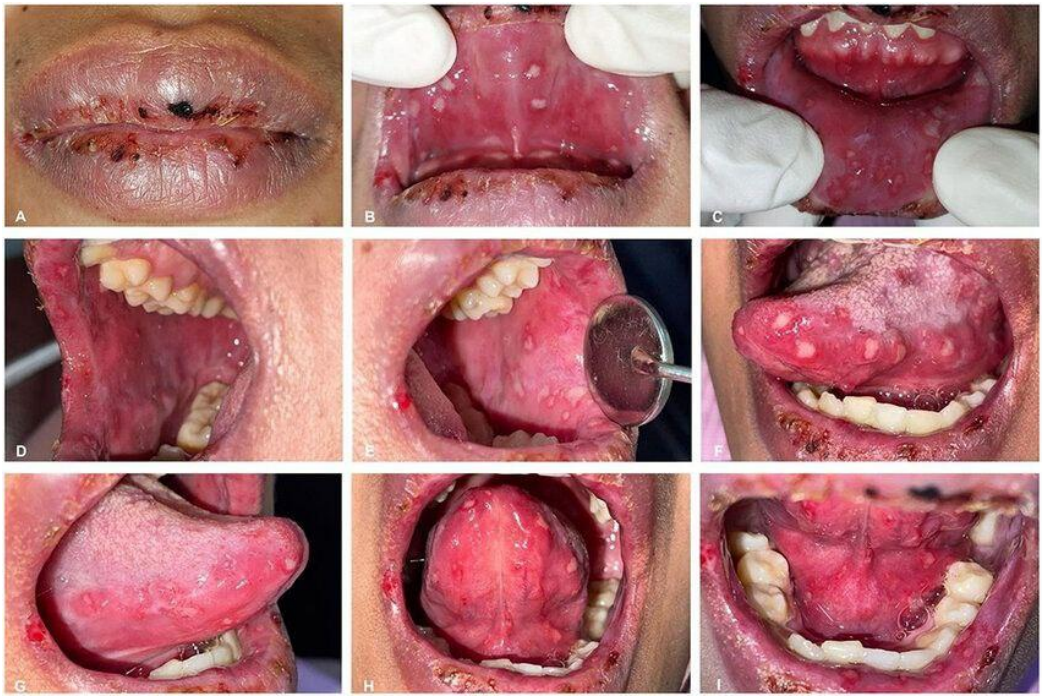

Figure 1. Clinical presentation at the first visit:

(A) Serosanguinous crusts on the lips with an erosive lesion at the right oral commissure, prone to bleeding;

(B–I) Irregularly shaped white ulcers with yellowish margins of varying sizes affecting the labial and buccal mucosa, the lateral and ventral surfaces of the tongue, and the floor of the mouth.

Background

Erythema multiforme (EM) is an acute mucocutaneous disorder that may occasionally be restricted to the oral cavity. Its association with electronic cigarette use has rarely been described, making such cases clinically significant.

Case Presentation

A 22-year-old female patient presented to the Department of Dentistry with complaints of painful oral stomatitis, burning sensation, and difficulty in eating and drinking. Symptoms began after fever

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and vesicular eruptions on the lips. The patient had been a regular user of electronic cigarettes (vaping) for approximately one year.

On extraoral examination, no lesions were observed elsewhere on the body. The lips were covered with serosanguinous crusts, with erosive areas at the commissures and a marked tendency to bleed. Intraoral examination revealed multiple irregular ulcers of varying size with whitish bases and yellowish margins across different areas of the oral mucosa (Fig. 1).

Laboratory Findings

Serological testing for HSV-1 IgG antibodies was negative, thereby excluding a herpetic etiology. Based on the clinical presentation and laboratory results, a diagnosis of **oral erythema multiforme** was established.

Management

Treatment included local compresses with 0.9% NaCl, dexamethasone-based mouth rinse, topical hyaluronic acid, 2% miconazole cream applied to the labial commissures, and petroleum jelly for lip hydration. Complete discontinuation of vaping was advised.

Outcome

After one week of therapy, the patient demonstrated substantial clinical improvement, with marked reduction in pain, healing of ulcers, and restoration of normal oral function (Fig. 2).

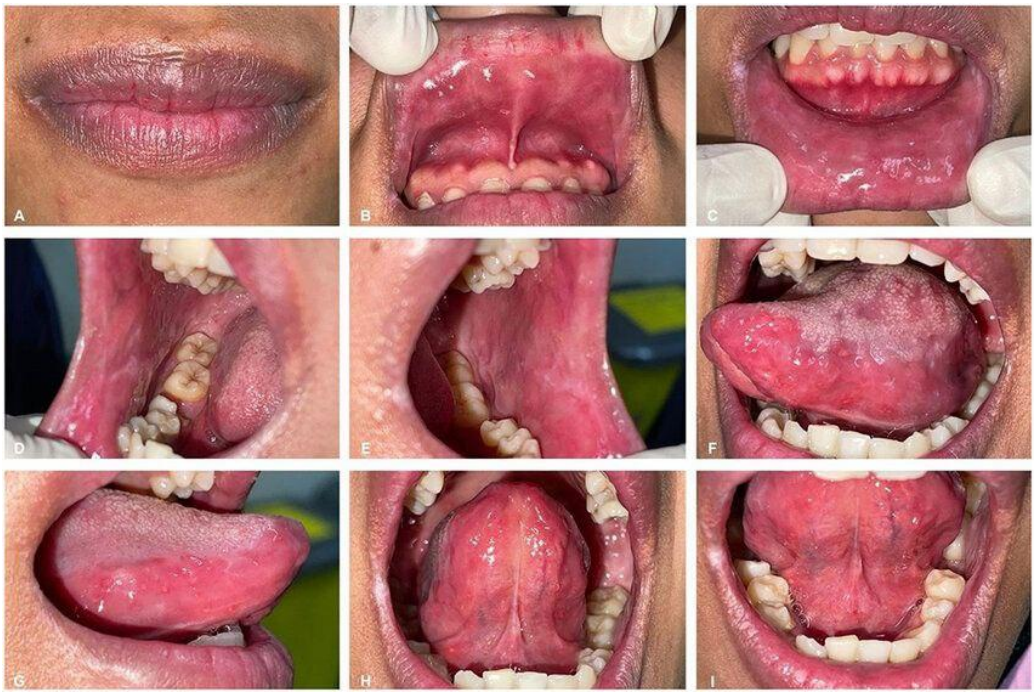

Figure 2. Clinical presentation at the second visit (after 7 days of therapy): (A, B) Healing of the lips and upper labial mucosa; (C–I) Noticeable improvement of the lower labial mucosa, buccal mucosa, lateral and ventral surfaces of the tongue, and the floor of the mouth.

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This case highlights a rare presentation of oral erythema multiforme potentially associated with electronic cigarette use. Early recognition of ulcerative oral lesions is essential for accurate diagnosis and timely treatment. Clinicians should maintain a high index of suspicion for EM when evaluating atypical oral ulcerations, particularly in young patients with a history of vaping.

Conclusion

Electronic nicotine delivery systems (ENDS), including vapes and e-cigarettes, cannot be regarded as safe alternatives to conventional smoking. Their components—nicotine, propylene glycol, glycerin, and flavorings—induce pathological changes in both soft and hard oral tissues. Altered salivary properties, microbial dysbiosis, chronic inflammation of the mucosa, and increased risks of gingivitis, periodontitis, candidiasis, and leukoplakia have all been documented. Enamel demineralization, hypersensitivity, and heightened caries risk further compromise oral health and aesthetics.

The presented case of oral erythema multiforme associated with vaping highlights the potential for severe immunopathological reactions. Encouragingly, clinical improvement after vaping cessation and topical therapy suggests that some effects are reversible with timely intervention.

In summary, vaping represents not just a harmful habit but a growing dental health challenge. Dentists must address its consequences clinically while actively educating patients—especially young people—about its risks.

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