




Electronic Cigarettes and Oral Health

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Abstract

Novel nicotine products, particularly electronic cigarettes (e-cigarettes), have become increasingly popular over the past decade. E-cigarettes are sometimes regarded as a less harmful alternative to tobacco smoking, and there is some evidence of their potential role as a smoking cessation aid. However, there are concerns about their health consequences, particularly in users who are not tobacco smokers, and also when used long term. Given the mode of delivery of these products, there is potential for oral health consequences. Over the past few years, there have been an increasing number of studies conducted to explore their oral health effects. In vitro studies have reported a range of cellular effects, but these are much less pronounced than those resulting from exposure to tobacco smoke. Microbiological studies have indicated that e-cigarette users have a distinct microbiome, and there is some indication this may be more pathogenic compared to nonusers. Evidence of oral health effects from clinical trials is still limited, and most studies to date have been small in scale and usually cross-sectional in design. Epidemiological studies highlight concerns over oral dryness, irritation, and gingival diseases. Interpreting data from e-cigarette studies is challenging, given the different populations that have been investigated and the continual emergence of new products. Overall, studies reveal potential oral health harms, underscoring the importance of efforts to reduce use in nonsmokers. However, in smokers who are using e-cigarettes as an aid to help them quit, the benefits of quitting tobacco smoking may outweigh any negative oral health impacts of e-cigarette use, particularly in the short term. Future research is needed to understand the clinical significance of some of the biological changes observed by following different cohorts of users longitudinally in carefully designed clinical studies and pragmatic trials supported by high-quality in vitro studies.

Keywords: electronic nicotine delivery systems, tobacco, dental research, periodontal diseases, nicotine, oral health

Introduction

Tobacco smoking is a major risk factor for oral diseases such as oral cancer and periodontitis (US Surgeon General 2014). Dental professionals have an important role to play in providing smoking cessation advice and support to their patients who smoke and in considering this risk factor when planning and providing dental treatment. Nicotine is the main psychoactive, chemically addictive component in tobacco smoke. Yet, it is now widely accepted that nicotine is not responsible for the general health harms that result from smoking (National Institute for Health and Care Excellence 2013; Stratton et al. 2018). Nicotine has been used therapeutically as a smoking cessation aid for over 3 decades in the form of nicotine replacement therapies (NRTs), and high-quality evidence supports NRT effectiveness.

Between 2006 and 2009, a new category of nicotine products started to emerge, electronic cigarettes or e-cigarettes. There are now over 40 million users of e-cigarettes worldwide, and in 2019, the industry was estimated to be worth over US\$19.3 billion per annum (British Broadcasting Corporation 2019). E-cigarettes generally contain 3 main categories of ingredients: a carrier solution (propylene glycol and/or vegetable glycerin), nicotine (although some e-cigarettes are nicotine free), and flavorings. E-cigarettes have proved to be controversial, and their potential risks and benefits have been extensively debated in many health and social care disciplines. From

a smoking cessation perspective, there is clinical trial evidence that they are an effective tobacco cessation aid when used in a specialist environment (Liu et al. 2018; Hartmann-Boyce et al. 2020), but large population-based studies have presented conflicting conclusions (Beard et al. 2020; Pierce et al. 2020). To date, many of the clinical trials have been conducted on specific populations (e.g., dependent smokers, with high rates of social disadvantages, and motivated to quit) and in specialist environments with expert support. It is likely that the effectiveness of e-cigarettes demonstrated in these trials will not be replicated in “real-world” settings, and it is important that future trials evaluate this. The regulation of e-cigarettes varies around the world, but in the United States, e-cigarettes have yet to receive US Food and Drug Administration (FDA) approval as quit aids (Lavacchi et al. 2020). It is important for dental professionals to understand if e-cigarettes are an effective smoking cessation aid as this will have substantial impacts on oral

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- ▶ Tobacco smoking is a major risk factor for oral diseases such as oral cancer and periodontitis
- ▶ Dental professionals have an important role to play in providing smoking cessation
- ▶ Nicotine is the main psychoactive, chemically addictive component in tobacco smoke
- ▶ **NICOTINE** is not responsible for the general health harms that result from smoking
 - ▶ used therapeutically as a smoking cessation aid for over 3 decades in the form of nicotine replacement therapies (NRTs)

- ▶ Between 2006 and 2009, a new category of nicotine products started to emerge, electronic cigarettes or e-cigarettes
- ▶ over 40 million users of e-cigarettes worldwide
- ▶ worth over US\$19.3billion per annum
- ▶ contain 3 main categories of ingredients:
 - ▶ a carrier solution (propylene glycol and/or vegetable glycerin)
 - ▶ nicotine (although some e-cigarettes are nicotine free)
 - ▶ flavorings

BE CONTROVERSIAL

Potential Merits

Potential effectiveness as a smoking cessation aid—clinical trial evidence reports that e-cigarettes are twice as effective as conventional nicotine replacement therapy

Plausibly less health harms than conventional tobacco smoking

Behavioral characteristics replicate habit—hand-to-mouth action, vapor production—for current smokers

Several features valued by current tobacco smokers who would otherwise resist other cessation strategies: range of flavors and designs, nonmedicinal background and marketing, accessibility

Potential Disadvantages

Effectiveness as cessation aid outside clinical settings (i.e., as consumer product) is unproven

As a quit aid, concerns over long-term use (users appear to use for longer than other products such as nicotine replacement therapy)

Unknown long-term health impacts

Regulatory approaches are varied around the world—rarely have e-cigarettes been regulated as strictly as medicinal products

Many features appeal to youth: range of flavors and designs, nonmedicinal background and marketing, accessibility

In some regions, uptake by youth has been rapid and widespread; nicotine dependence common among youth users

Concerns over health harms such as brain development in adolescence

Some marketing and advertising have substantial youth appeal

Dual use of e-cigarettes and conventional cigarettes together is common and may cause harms similar to conventional smoking alone

- ▶ Tobacco smoking is responsible for considerable morbidity and mortality, with
 - ▶ half of all smokers dying from a smoking related disease such as cancer, respiratory disease, or vascular disease
- ▶ e-cigarettes emit fewer toxicants than tobacco smoking
- ▶ systematic review (2-y follow-up) did not identify evidence of harmful effects caused by nicotine-containing e-cigarettes
- ▶ Several other reviews have identified possible cardiovascular and respiratory harms and potential harms on the developing adolescent brain

Hot stuff bias

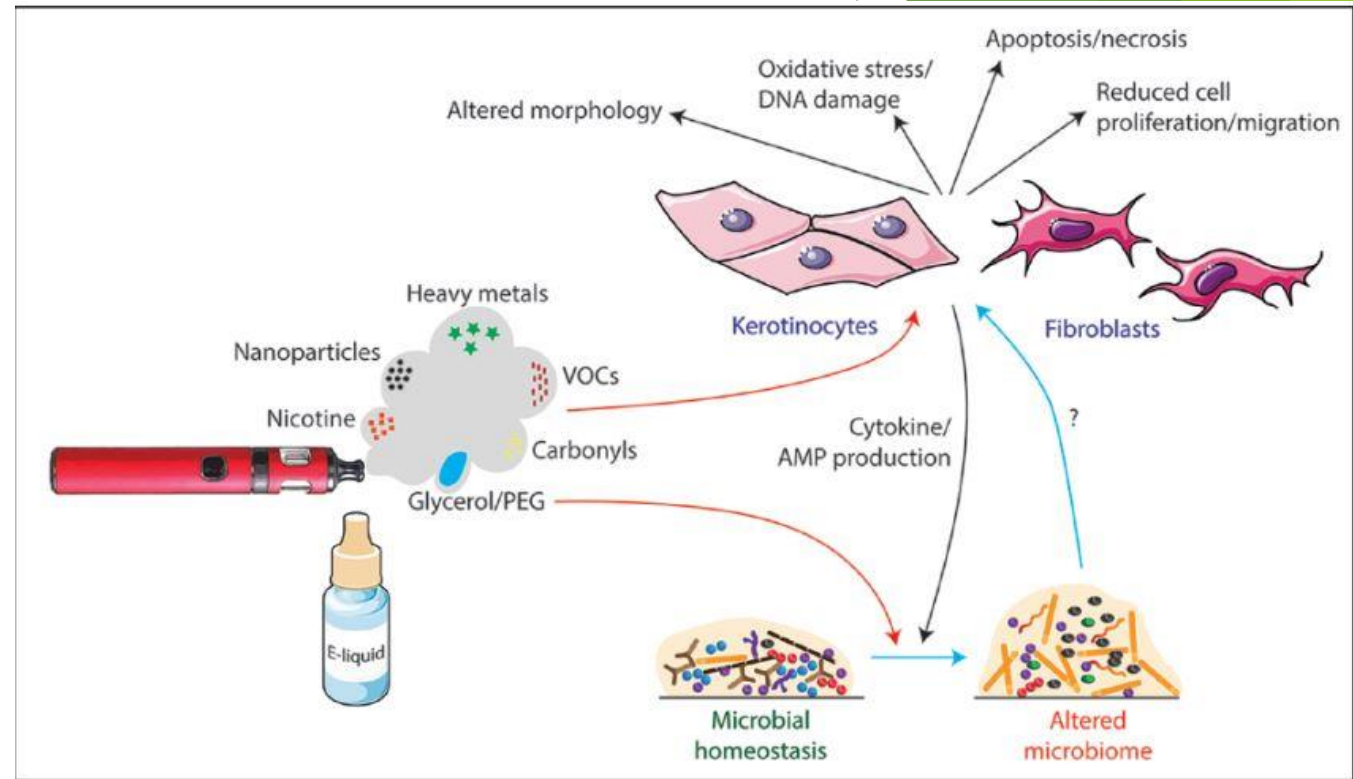
- ▶ When a topic is new or fashionable, investigators may be less critical in their approach and journal reviewers and editors not as rigorous as they might otherwise be given the temptation to publish results

In Vitro Evidence

- ▶ Toxicology studies have identified many components in e-cigarette aerosol (sometimes called vapor) that are hazardous to health, including;
 - ▶ nanoparticles, volatile organic compounds, carbonyls, heavy metals, and nicotine
- ▶ 15 studies have investigated in vitro effects of e-cigarette exposure on 2-dimensional or 3-dimensional cell culture models
- ▶ Early studies tended to expose cells directly to e-liquids
- ▶ E-cigarette aerosol extracts, prepared from custom-made extraction machines, added to the cell culture medium

In Vitro Evidence

- ▶ Cytotoxicity
- ▶ reduced cell proliferation and migration
- ▶ increased apoptosis
- ▶ inflammatory mediator production
- ▶ detection of oxidative damage such as protein carbonylation and DNA strand breaks



- ▶ Tobacco smoke extract exposure was highly toxic
 - ▶ 24 h without causing excessive cell death
 - ▶ E-liquid extract survived for up to 8 wk, with new extract being added every 3d

It is important not to extrapolate directly from experimental results obtained in vitro to the clinical situation

Microbiological Evidence

- ▶ Depletion of Proteobacteria and enrichment for Firmicutes and Actinobacteria in smokers
- ▶ use of e-cigarettes may influence the profile of the oral microbiome toward a state that is distinct from that present in nonsmokers or tobacco smokers
- ▶

Evidence from Clinical Studies

- ▶ cytologic examination of oral mucosa scrapings was performed;
 - ▶ cell damage was significantly decreased in the e-cigarette group (as compared to current smokers), being similar to that seen in healthy controls (never smokers)
- ▶ tobacco smoke with increased risk for periodontitis and peri-implant disease
 - ▶ risk of periodontal disease associated with e-cigarette use is less than that associated with tobacco smoking **but more than that seen in nonsmokers**
 - ▶ Clinical improvements in those with preexisting periodontal disease when participants quit smoking and switched to using e-cigarettes, with and without periodontal therapy
- ▶ increased bleeding with e-cigarette use
 - ▶ smokers who were asked to switch to an e-cigarette for 2wk, observed an increase in bleeding on probing during the time of e-cigarette use

Epidemiological Evidence

- ▶ presence of oral mucosal, tongue, or ulcerative lesions in patients who use e-cigarettes
- ▶ dry mouth and mouth or throat irritation as common symptoms among e-cigarette users