

Oral Health of Smokers and E-Cigarette Users: A Case-Control Study

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Abstract

The objective of this study was to evaluate and compare the oral health of cigarette smokers, e-cigarette smokers, and non-smokers. This observational study involved 120 participants; 40 each in the control, cigarette, and e-cigarette groups respectively. Oral health examination was conducted according to the World Health Organization (WHO) criteria. Dental caries was evaluated using the DMFT index, while the periodontal parameters assessed using plaque, gingivitis, gingival bleeding, and calculus indices. The results from the 3 groups were compared using analysis of variance (MANOVA), the outcomes of which were significant for the Gingival Index ($p = 0.000$), Plaque Index ($p = 0.012$), and Bleeding Index ($p = 0.001$) of periodontal health. Post-hoc tests with Bonferroni correction revealed significant differences in the Gingival Index between the control and cigarette groups ($p = 0.001$), as well as cigarette and e-cigarette groups ($p = 0.000$). Meanwhile, Bleeding Index was only significantly different between the control and e-cigarette groups ($p = 0.001$). For Plaque Index, significant differences were seen between the control and cigarette groups ($p = 0.016$). There were no significant differences in the other periodontal health parameters, as the p values of the Calculus Index and DMFT Index were 0.955 and 0.702 respectively. In conclusion, e-cigarettes had potentially detrimental effects on oral health.

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Introduction

Smoking has been identified as a major risk factor of lung cancers, apart from heart, peripheral vascular, and respiratory diseases¹. There are a number of well-established detrimental effects of smoking on the oral cavity. These include periodontal diseases, impaired wound healing, dental caries, precancerous lesions, and risk of oral carcinoma². Recently, there is an increase in the popularity of alternative types of cigarettes, namely electronic nicotine delivery system (ENDS) or electronic cigarettes (e-cigarettes)³. E-cigarettes are electrical devices that vaporize propylene or polyethylene glycol-

based liquid solutions to give an aerosol mist containing various concentrations of nicotine⁴.

Although the current government policy on nicotine control is being established to include e-cigarettes, this industry is almost completely unregulated in Malaysia at time of writing this article. There are no product standards that for controlling the levels of dosing, contaminants, toxins, and carcinogens in the liquids used in e-cigarettes as well as the aerosols they produce⁵. In light of the fact that e-cigarettes are neither cigarettes nor smokeless tobacco, they evade the advertising bans that have been in place for decades for the aforementioned tobacco products.

To date, there is little documented evidence on the oral effects of e-cigarette usage. A short observational study conducted in 2011 reported mouth irritation, sore throat, dry mouth, and oral ulcers after 4 weeks of use⁶. Although clinical studies on the said topic are scarce, high levels of nicotine suggest that these products may increase the risk of periodontal damage⁷. In fact,

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the effects of cigarette smoking on health have been reported in numerous past studies, including those conducted in Malaysia⁸. However, the findings of the studies on the effects of e-cigarette on oral health were few and inconsistent.

In view of the conflicting evidences on the oral health of cigarette and e-cigarette users, the aim of this study was to compare the occurrence of caries and periodontal health status between the control group (non-cigarette and non-e-cigarette users), cigarette users, and e-cigarette users.

Methodology

Sample size

This study was approved by IIUM Research Ethical Committee (IREC). The sample size calculation was done using the Openepi software (version 3.01)⁹. Data from previous studies indicated that the occurrence of the outcome was 31% among the exposed groups. Based on this assumption, along with a Type 1 error of 95% and type 2 error of 80%, a sample size of 34 was required for each arm. Hence, the minimum total sample size needed was 102. However, after allocating for a 10% dropout rate, the aforementioned number became 113, or 38 participants for each arm.

The participants were divided into three groups: control, cigarette users, and e-cigarette users. The dental examination was conducted at the Kulliyyah of Dentistry Specialist Clinic. On the day of clinical examination, each participant was given a participant information sheet. After being informed about the aims and nature of the study, they were asked to sign a consent form.

Dental examination

Dental examination was performed by a single trained examiner, with the respondent on a dental chair. The equipment used for the exercise included dental mirrors, dental explorers, periodontal probes, and an overhead light from the dental chair. All data were recorded in clinical forms (one form for each participant).

Dental caries

The dental caries statuses of the participants were assessed using the DMFT/dmft Index (10). All the permanent teeth were

examined visually for caries. DT/dt referred to the number of decayed permanent teeth, MT/mt missing permanent/ primary teeth due to caries, and FT/ft filled permanent/ primary teeth.

Periodontal parameters

The periodontal health of the participants was measured using the Plaque Index¹¹, Gingival Index¹², Gingival Bleeding Index, and Calculus Index¹³. The dentition was divided into 6 sextants, each with 1 index tooth, i.e. maxillary right first molar, maxillary right lateral incisor, maxillary left first bicuspid, mandibular left first molar, mandibular left lateral incisor, and mandibular right first bicuspid. This was in accordance to the method proposed by¹². Index teeth that were missing, mobile, or erupted were excluded from the examination.

Statistical analysis

All data was analyzed using the Statistical Package for Social Sciences (SPSS) software (version 23.0) (SPSS Inc, Chicago, Ill., USA). Means and standard deviations were calculated for the continuous data. Meanwhile, the differences in the caries statuses and periodontal health between the cigarette, e-cigarette, and control groups were compared using MANOVA according to a normal data distribution. The level of statistical significance was set at 0.05.

Results

A total of 120 participants were included. The mean age for the control group was 29.78 years, while that for the cigarette and e-cigarette groups was 30.28 and 22.92 years respectively. Most of the participants in the control group were females (72.5%); males were predominant in the cigarette and e-cigarette groups (97.5% each). Besides, the majority of the participants were Malays (99.1%); there was only one Indian. As for level of education, the majority of participants in the control group had tertiary education (95%). In contrast, e-cigarette users had the least number of participants with tertiary education (25%). Regarding monthly income, 87.5% of the e-cigarette users earned less than RM 2 000, whereas 37.5% of respondents in the control group and 20% of cigarette users were in this bracket. These demographic data are presented in Table 1.

MANOVA test was conducted to evaluate the relationship between smoking and oral health. Following statistical analysis (Table 2), there were significant findings only for Gingival Index ($p = 0.000$), Plaque Index ($p = 0.012$), and Bleeding Index ($p = 0.001$). The converse was true for Calculus Index and DMFT Index. Post-hoc test with Benferroni correction revealed significant differences in the Gingival Indices between Control and Cigarette groups ($p =$

0.001) as well as Cigarette and E-cigarette groups ($p = 0.000$). Meanwhile, e-cigarette usage resulted in a significant change in the Bleeding Index with respect to the control group ($p = 0.001$). For Plaque Index, there were significant differences between control and cigarette groups ($p = 0.016$). Smoking had no significant effect on the other periodontal health parameters like the Calculus Index and DMFT Index as the p values were 0.955 and 0.702 respectively.

| Characteristics | Control Group n (%) n=40 | Cigarette Users n (%) n=40 | E-cigarette Users n (%) n=40 |
|-------------------|--------------------------------|----------------------------------|------------------------------------|
| Mean Age (M ± SD) | 29.78 ± 9.74 | 30.28 ± 8.31 | 22.92 ± 2.91 |
| Gender | | | |
| Male | 11 (27.5) | 39 (97.5) | 39 (97.5) |
| Female | 29 (72.5) | 1 (2.5) | 1 (2.5) |
| Race | | | |
| Malay | 39 (97.5) | 40 (100) | 40 (100) |
| Indian | 1 (2.5) | 0 (0) | 0 (0) |
| Chinese | 0 (0) | 0 (0) | 0 (0) |
| Education | | | |
| Primary School | 0 (0) | 0 (0) | 0 (0) |
| High School | 2 (5) | 15 (37.5) | 30 (75) |
| University | 38 (95) | 25 (62.5) | 10 (25) |
| Income | | | |
| Below RM2000 | 15 (37.5) | 8 (20) | 35 (87.5) |
| RM2000-RM5000 | 23 (57.5) | 29 (72.5) | 5 (12.5) |
| Above RM5000 | 2 (5) | 3 (7.5) | 0 (0) |

Table 1. Demographic characteristics of control, cigarette, and e-cigarette groups.

| Parameter | Group | n | Mean (SD) | CI (%) | P-value |
|----------------|-------------------|----|--------------|--------------|--------------------|
| Gingival Index | Control Group | 40 | 34.45(32.20) | 24.96, 43.94 | 0.000 ^b |
| | Cigarette Users | 40 | 60.19(31.80) | 50.70, 69.68 | |
| | E-cigarette Users | 40 | 32.20(26.62) | 22.67, 41.67 | |
| Plaque Index | Control Group | 40 | 27.07(25.80) | 18.50, 35.65 | 0.012 ^b |
| | Cigarette Users | 40 | 44.42(30.88) | 35.84, 53.00 | |
| | E-cigarette Users | 40 | 30.00(25.16) | 21.40, 38.54 | |
| Bleeding Index | Control Group | 40 | 13.17(17.76) | 6.94, 19.40 | 0.001 ^b |
| | Cigarette Users | 40 | 20.52(22.70) | 14.30, 26.75 | |
| | E-cigarette Users | 40 | 30.10(18.86) | 23.87, 36.32 | |
| Calculus Index | Control Group | 40 | 19.44(14.80) | 13.88, 25.00 | 0.955 |
| | Cigarette Users | 40 | 20.51(18.41) | 14.96, 26.07 | |
| | E-cigarette Users | 40 | 19.50(19.70) | 13.93, 25.06 | |
| DMFT Index | Control Group | 40 | 3.65(3.76) | 2.64, 4.68 | 0.702 |
| | Cigarette Users | 40 | 3.23(3.92) | 2.20, 4.25 | |
| | E-cigarette Users | 40 | 3.05(1.66) | 2.02, 4.08 | |

Table 2. Means of periodontal health for control, cigarette, and e-cigarette groups.

a MANNOVA test used for statistical analysis.

b Only the means of (1) Gingival Index between “control group and cigarette users ($p = 0.001$)” and “cigarette users and e-cigarette users ($p = 0.000$)”, (2) Plaque Index between “control group and cigarette users ($p = 0.016$)” as well as (3) Bleeding Index between “control group and e-cigarette users ($p = 0.001$)” were significantly different in the post-hoc test with Bonferroni procedure.

Discussion

The present study evaluated and compared the oral health of the control, cigarette, and e-cigarette groups. The ages of our participants varied considerably (20 – 64 years), whereby the means were 29.78, 30.28, and 22.92 years for the control, cigarette, and e-cigarette groups. These findings further supported the idea that e-cigarette users were relatively younger; their average age is 19 years¹⁴ as compared to 34 years for the cigarette users¹⁵.

The link between smoking and periodontal attachment loss has been frequently reported in epidemiological studies. Besides, the gingival appearance in chronic smokers is known to be disease-masking as the gingiva bleeds less and appears hardened as compared to that of non-smokers. The vasoconstrictive properties of cigarette smoke reduce gingival inflammation. However, advanced periodontitis could be happening in light of the propagation of the underlying inflammatory process¹⁶. These findings further imply that those who use tobacco are at an increased risk of periodontitis, regardless of the type of tobacco⁷. Furthermore, there is clear evidence¹⁷ that vasoconstriction, which is promoted by nicotine, can cause peripheral vasoconstriction and lead to reduced blood supply¹⁸. Thus, the results observed in our study could explain the harmful effects of tobacco and nicotine on periodontal health.

However, in relation to the control group, the difference in the Bleeding Index was only significant for e-cigarette users but not cigarette users. This occurrence raises a big question because e-cigarettes are regarded to be less harmful to health and an alternative way for smoking cessation¹⁹. It was reported that the usage of e-cigarettes that contain nicotine increased capillary perfusion to the buccal mucosa²⁰. In addition, previous animal studies have demonstrated enhancements in the muscular and intestinal blood flow, but reductions in the peripheral perfusion¹⁷. Hence, in our study, it can be inferred that the oral mucosa blood flow was affected by e-cigarettes.

With regards to the occurrence of caries, the absence of significant differences between the control, cigarette, and e-cigarette groups in this research was unexpected. The reason behind this is not very clear, especially since

smoking has been linked with increased incidence of dental caries²¹. As such, the findings of the current study did not support those of the previous researches. On the other hand, it has also been suggested that the increase in caries development was independently related to the level of tobacco consumption²². There is a consensus among prominent researchers over the link between the two aspects. In addition, there are significant increases in the numbers of decayed, missing, and filled teeth in people who smoke more than 15 cigarettes daily²³. A research has also reported that soldiers who smoked were more likely to have dental caries^{24,25}. In short, recent and prominent studies have established the correlation between smoking status and caries occurrence.

To date, there are still very few studies on the oral health of cigarette and e-cigarette users. The results of our study can be a reference for comparing the detrimental effects of cigarette and e-cigarette smoking on the oral health with respect to non-smokers. Moreover, it explained the harmful effects of tobacco and nicotine on periodontal health as well.

Conclusion

In conclusion, this study has shown that e-cigarettes had potentially undesirable effects on oral health. Evidently, there is an increase in the number of e-cigarette users around the globe because of the general belief that e-cigarettes are less harmful as compared to conventional cigarettes. As such actions must be taken to rectify this occurrence. More research needs to be done to provide evidence of the effects of e-cigarettes on health, specifically oral health.

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