E-cigarettes effect on periodontal health: a systematic review

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ABSTRACT

Background: *Smoking is well known risk factors that promote periodontal tissue destruction. Both smoking and periodontitis nowadays consider as a common health problem globally. As smoking habit evolution, electronic cigarettes (E-cigs) have emerged as an alternative to cigarettes. The number of E-cigs smoker or vaping users around the world are increasing. However, information about the effect of E-cigs on periodontium is very lacking lately. The study aimed to compare the effect of cigarette consumption on periodontium by clinical health parameters between all smokers' type.*

Method: *This review follows the PRISMA guidelines. Document search was carried out in PubMed, Ebsco Host and Scopus using the keywords or phrases: (periodontal health) AND (((((electronic cigarette) OR Vaping) OR e-cig) OR electronic nicotine delivery system) OR nicotine delivery system). A total of 137 articles were obtained after the duplicates were eliminated and five articles were considered met the eligibility criteria for systematic review.*

Result: *This review found that E-cigs are less harmful compared to tobacco cigarettes, with comparable result between E-cigs smoker and non-smoker on some clinical periodontal health parameters for mean probing depth, clinical attachment loss, score of plaque index (PI) and papillary bleeding index (PBI) as well. In contrast, the study reveals that bleeding on probing level was higher among non-smokers than smokers.*

Conclusion: *E-cigs are less harmful compared to tobacco cigarettes on some clinical periodontal health parameters. This result should be interpreted with caution because there is currently insufficient data to investigate the effect of E-cigs on periodontal health through clinical parameters.*

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INTRODUCTION

Smoking-related diseases are a well-known public health issue that affects people all over the world.[1–3] According to WHO data, the smoking prevalence among people aged 15 years in high income countries is expected to be 22.4% in 2020 and 20.5% in 2025 for both sexes. In the meantime, WHO projected 22.4% and 20.5% for upper middle-income countries, against the 10.7% and 9.8% for the low-income countries. The projected data show a decrease from 2020 to 2025, but WHO estimates that 10% of deaths in 2020 will be caused by smoking.[4] As a result, smoking has become one of the world's major public health issues.[2,5]

Periodontal diseases are oral disease that ranks first in the 2001 world book record as a common disease that is often found in the community.[6] Periodontitis, due to its high prevalence, is known as major global oral health problem. Periodontitis can negatively affect the tooth supporting structure lead to a decreasing of periodontal support to the teeth, impairing tooth function on mastication and also facial aesthetic, being the initial source of systemic infection and of course impairing the host quality of life.[7–9] Study from 1990-2010 showed that severe periodontitis was the sixth highest prevalence of the disease (11.2%) with an increase in prevalence of 57.3% in 10 years.[6,10] Smoking is well known risk factors that promote periodontal tissue destruction.[11] Both smoking and periodontitis nowadays consider as a common health problem globally.[7,12]

Some countries now have laws that regulate and limit tobacco use in public places. Electronic cigarettes (E-cigs) have emerged as a popular alternative to cigarettes among adolescent smokers for the first time or former smokers who prefer E-cigs to be used for smoking cessation. The effects of E-cigsor vaping on oral health, particularly periodontal tissue, are rarely reported in the literature.[3]

The use of E-cigs are increasing around the world, but more research into its effect on periodontal tissue is needed. On that basis, the purpose of this systematic review was to examine the current evidence and compare the effect of E-cigs and other types of smokers on periodontal tissue health using available clinical parameters.

LITERATURE REVIEW

Data Selection

The guidelines for PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) are based on the results of this systematic review. We set a review question based on the PICO strategy: "Will E-cigarette smokers (ES) have a better clinical periodontal health parameter when compared to non-smokers (NS) and smokers?". Smokers were designated as the population (P), ES as the intervention (I), and NS, conventional smokers (CS), or other types of smokers as the comparison (C), with clinical periodontal health as the outcome (O).

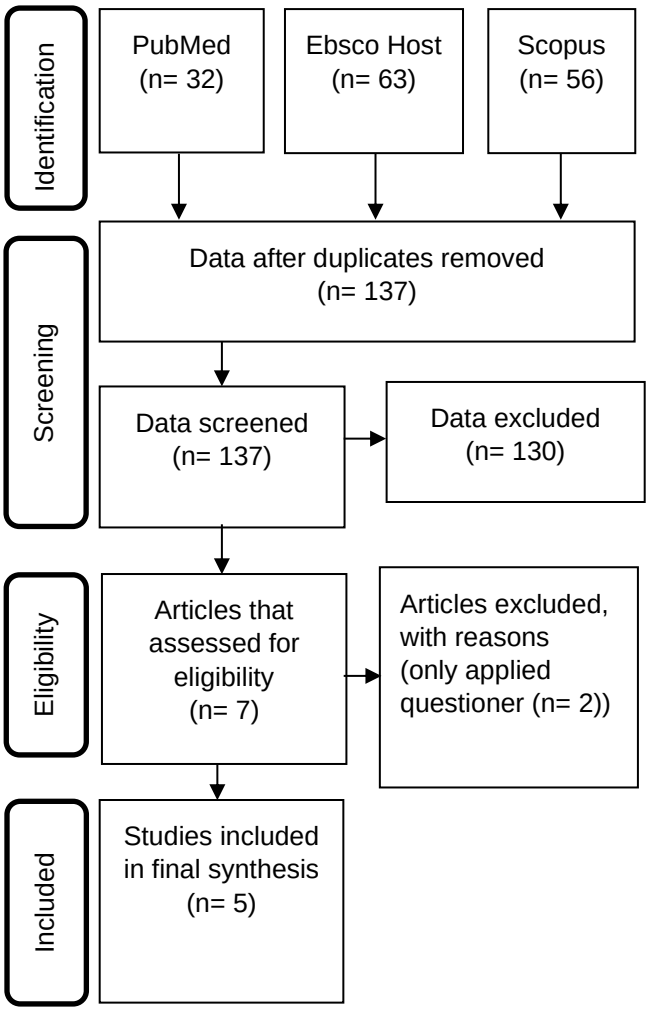

Figure 1. Flowchart of article selection according to PRISMA, five articles were considered met the eligibility criteria for final review.

An Internet search was conducted in PubMed, Ebsco Host, and Scopus using the keywords or phrases: (periodontal health) AND (((((electronic cigarette) OR Vaping) OR E-cigs) OR nicotine delivery system) OR electronic nicotine delivery system) OR electronic nicotine delivery system) with full text filters for the 2010-2020 document. The most recent search took place on December 24th, 2020. Observational or analytical studies that evaluated at least one clinical periodontal health parameter were included in the review. Exclusion criteria for the study included an article review, cell and/or animal studies, and questionnaire-based studies.

Two independent authors manually removed the duplicate references using a Microsoft Excel 2016 spreadsheet (Microsoft USA). The initial selection was done through titles and abstracts, and the final quality checks on the studies included in the final review were done by independent authors using the ROBIN-I methodological index, which followed the same guidelines as Ralho et al.[3]

Result

In the initial literature search, 151 articles were discovered, with 32 articles coming from PubMed, 63 from Ebsco Host, and 56 from Scopus. After removing duplicates, a total of 137 articles were obtained, of which 7 were chosen through title and abstract screening. Five articles were considered eligible for the final systematic review (Figure 1).

All of the articles included in the systematic review were published between 2016 and 2020. The studies included in the systematic review were classified into four types: case control studies[13,14], cross-sectional observational studies[15], a pilot cross over study design[16], and clinical observational pilot studies[1].

Table 1. Demography of the studies eligible for the final review

Author	Sample	Parameter						
		Subjects Number	Male: Female	Age in years (mean ± SD)	Duration of smoking habit (in years)	Daily frequency of habit	Duration of each session in minutes (mean ±SD)	Family history of smoking (%)
Javed et al., 2017 [13]	NS	30	30:0	40.7 ± 1.6	-	-	-	23.3
	ES	31	31:0	37.6 ± 2.1	2.2 ± 0.2	6.8 ± 0.8	NI	60.6
	CS	33	33:0	41.3 ± 2.8	5.4 ± 1.6	13.3 ± 2.6	NI	68.5
BinShabaib et al., 2019 [15]	NS	45	39:6	40.6 ± 3.3	-	-	-	NI
	ES	44	42:2	36.5 ± 1.7	9.4 ± 2.6	NI	20.3 ± 3.5	NI
	CS	46	43:3	44.2 ± 3.5	14.2 ± 0.6	NI	5.2 ± 0.6	NI
Mokeem et al., 2018 [14]	NS	38	38:0	40.6 ± 4.5	-	-	-	28.9
	ES	37	37:0	28.3 ± 3.5	3.1 ± 0.4	9.2 ± 1.4	8.1 ± 1.3	27.0
	CS	39	39:0	42.4 ± 5.6	17.2 ± 2.5	16.2 ± 2.5	4.8 ± 0.3	58.9
	WS	40	40:0	44.7 ± 4.5	14.6 ± 5.7	4.3 ± 0.5	17.1 ± 3.4	67.5
Wadia et al., 2016 [16]	ES	18	NI	18-65	NI	NI	NI	NI
	CS	19	NI	18-65	NI	NI	NI	NI
Tatullo et al., 2016 [1]	ES1	60	89:21	31 ± 9	NI	NI	NI	NI
	ES2	50			NI	NI	NI	NI

CS (Conventional Cigarette Smoker); ES (Electronic Cigarette Smoker); ES1,2 (ES group 1,2); NA (No Information); NS (Non-Smoker); WS (Waterpipe Smoker)

The demographics of the included studies (table 1) showed a total of 530 subjects from all included studies. Except for Wadia et al (2016) all studies that specified the gender of subjects were included[16], . The subjects of included studies were 461 males and 32 females. Two studies[13,14] included only male subjects. The subjects' ages ranged from 18 to 65 years old.

The risk of bias assessment (table 2) was performed as part of the quality assessment for studies that were eligible for the final review. For each risk of bias parameter, the quality assessment was graded using a five-point scale: Y (Yes), PY (Probably Yes), N (No), PN (Probably No), and NI (No Information). For the Mokeem et al (2018), study, reviewer judgement for pre-intervention biases including confounding biases was low risk, while moderate risk was applied for biases in participant selection due to possibly biases.[14] There was a low risk of bias in reviewer judgment for the intervention postintervention phases.

Five clinical parameters were recorded on studies to assess periodontal health: bleeding on probing (BoP) score, probing depth (PD) score, clinical attachment loss (CAL) score, plaque index (PI) score, and the last papillary bleeding index (PBI) score. PI was evaluated in all of the studies that were included. Except for Tatullo et al.,[1] all studies evaluated BoP, PD, and CAL.

Table 3 summarizes the findings from the five studies that qualified for the final review. Because of the disparity in methodology and clinical parameters assessed in the included studies,

quantitative analysis on this systematic review was not possible.

Table 2. Quality assessment for risk of bias of the studies included in final review.

Studies	Pre-intervention		At intervention	Post-intervention			
	Risk of bias parameter						
	confounding	selection of participants into the study	interventions classification	intended interventions deviations	missing data	outcomes measure-ment	reported result selection
Javed et al., 2017 [13]	PN	N	N	N	N	PN	N
BinShabaib et al., 2019 [15]	N	N	N	N	N	N	N
Mokeem et al., 2018 [14]	PN	PY	N	N	N	PN	N
Wadia et al., 2016 [16]	PN	N	N	N	N	PN	N
Tatullo et al., 2016 [1]	PN	N	N	N	N	N	N
Risk of Bias Judgement	Low risk	Moderate risk	Low risk	Low risk	Low risk	Low risk	Low risk

PY (Probably Yes), N (No), PN (probably No)

Table 3. E-cigs effect on periodontium by clinical health parameter

Author	Study type	Subject criteria	Sample	Clinical Periodontal Health Parameter Evaluated				
				BoP (%)	PD (%)	CAL (mm)	PI (%)	PBI
Javed et al., 2017 [13]	Case control study	1. CS (Daily frequency ≥5 cig/day ≥1 year); 2. ES (Using ≥1 year without tobacco use); 3. NS	NS (n=30)	27.5±3.2	≥4mm: 29.3±1.7	0.8±0.1	21.4±2.8	NA
			ES (n=31)	4.6±2.9*	≥4mm: 5.1±1.2	1.1±0.2	23.3±3.4	NA
			CS (n=33)	5.8±0.8*	≥4mm: 29.3±1.7*†	2.1±0.2	52.1±6.6*†	NA
BinShabaib et al., 2019 [15]	cross-sectional observational study	1. CS (Daily frequency ≥5 cig/day ≥1 year); 2. ES (Just using E-cigs at least 1/day); 3. NS	NS (n=45)	28.4[b] (26.3–33.4)	1.6 (1.2–2.2)	0.6 (0.5–1.2)	18.2 (23.5–34.3)	NA
			ES (n=44)	12.2 (14.4–20.5)	2.5 (2.2–3.4)	1.7 (0.5–1.4)	33.4 (29.6–39.7)	NA
			CS (n=46)	10.6 (15.5-22.4)	5.3[a] (4.4–6.3)	2.8[a] (1.8–3.1)	42.1[a] (40.3–46.3)	NA
Mokeem et al., 2018 [14]	Case control study	1. CS (Daily frequency ≥5 cig/day ≥1 year); 2. ES (≥1 year); 3. WS (≥1/day ≥1 year); 4. NS	NS (n=38)	Reference	Reference	Reference	Reference	NA
			ES (n=37)	**	ND	ND	ND	NA
			CS (n=39)	**	a	a	**	NA
			WS (n=38)	**	a	a	**	NA
Wadia et al., 2016 [16]	A pilot cross over study design	1. CS (Daily frequency ≥10 cigarettes/ day ≥5 years), then replaced smoking habits to E-cig for 2 weeks (ES).	ES (n=18)		ND	NA		NA
			CS (n=18)	CS significantly higher than ES	2 ±0.43mm	NA	ND	NA
Tatullo et al., 2016 [1]	Clinical observational pilot study (120 days with 3 different check-points)	1. ES approximately from 4±1 month 2. ES1 (< 10 years of tobacco smoking) 3. ES2 (> 10 years of tobacco smoking)	ES1 (n= 60)	NA	NA	NA	T_0: 0.9±0.3 T_1: 0.8±0.4 T_2: 0	T_0: 0.4±0.49 T_1: 0.2±0.4 T_2: 0
			ES2 (n= 50)	NA	NA	NA	T_0: 2.13±0.5 T_1: 1.63±0.7 T_2: 0.25±0.45	T_0: 1.25±1.34 T_1: 0.25±0.45 T2: 0

BoP (Bleeding on Probing); CAL (Clinical Attachment Loss); CS (Conventional Cigarette Smoker); ES (Electronic Cigarette Smoker); NA (Not applicable); ND (Not significantly different); NS (Non-Smoker); PBI (Papillary Bleeding Index); PD (Probing Depth); PI (Plaque Index); T_{012} (first, second and third checkpoint); WS (Waterpipe Smoker); * Significant difference compared with group NS (P<0.01); ** Significant difference compared with group NS (P<0.05); † Significant difference compared with group ES (P<0.01); [a] Compared with Group ES (P < 0.05) and Group NS (P < 0.05); [b] Compared with Group CS (P < 0.05) and Group ES (P < 0.05).

DISCUSSION

Adolescent's general perception of E-cigs compared to conventional cigarettes is considered to be less harmful[17] and less addictive[18,19]. Escalating use of E-cigs may be partly due to public perception about E-cigs are less harmful dan smoke cigarettes.[20–24]

Most of former smokers' belief that by using E-cigs, they are less risky, and can be a substitute and helpful for cigarettes smoking cessation,[25,26] and this systematic review confirms that believe. This review found that E-cigs are less harmful compared to tobacco cigarettes, with comparable result between E-cigs smoker and non-smoker on some clinical periodontal health parameters for mean probing depth, clinical attachment loss, score of plaque index (PI) and also papillary bleeding index (PBI). In contrast, the study reveals that bleeding on probing level was higher among non-smokers than smokers. This result should be interpreted with caution because there is currently insufficient data to investigate the effect of E-cigs on periodontal health through clinical parameters.

Bleeding on probing (BoP) is one of the fundamental clinical parameter health for periodontium. BoP related to early sign of clinical inflammation on periodontium. BoP can be found in early lesion of gingivitis and can be visualized earlier than redness and swelling.[27] Three studies reported that BoP site significantly higher in NS subjects comparing to ES or CS with no differences between ES and CS.[13–15] Study by Wadia et al. (2016) reported that when subject switch the smoking habit from CS to ES, the number of BoP site are increased.[16] Subject who was waterpipe smoker has a lower BoP site compared to non-smoker as reported by Mokeem et al.[14]

Nicotine, which found in tobacco cigarette and E-cigs liquid, has known to decreasing the gingival bleeding response due to its vasoconstrictive effect on gingival blood vessel.[1,28] This vasoconstriction effect also impairing the gingival crevicular fluid (GCF) by decreasing the GCF flow rate. Thus, potentially impairing the homeostasis between host response to intraoral microbiome. Nicotine is also known to reduce cellular healing potential.[1,3] ES just like CS may unaware of oral inflammatory change escalation due to less perceptible of bleeding on their periodontium compared to non-smokers.[3]

Another bleeding parameter was Papillary Bleeding Index (PBI). Out of five study included in review, only Tatullo et al.,[1] showing the parameter of PBI. Tatullo et al.,[1] showing when CS switched to ES, there are constant reduction of PBI. Subject with more than 10 years of tobacco smoking habit (ES2) have a marked reduction of PBI when compared from initial (T_0) to the last observational period (T_2).

Probing depth (PD) and clinical attachment loss (CAL) alone are insufficient indicators of periodontal health or disease because they are insufficient parameters to predict the sites with potential infection or experience of disease recurrency. However, both PD and CAL can be useful when combined with BoP information.[27] A significant higher PD in CS were observed by three studies compared to ES and NS, while no difference between ES and NS.[13–15] When smokers switch from CS to ES, no differences in PD were observed.[16] However, must be noted that in Wadia et al.(2016) ,studies, the initial mean of PD was 2 ±0.43mm and included sample has PD ≤4 mm at any site. [16] .

In terms of CAL, only Javed et al. (2017) not found that CAL is higher in CS than in ES and NS.[13] Nicotine consumption both the frequency and duration was nearly twice as high among CS as it was among ES.[13] . This study demonstrated that CAL are insufficient evidence of periodontal health

or disease. Previous research has also confirmed that CS have a significantly higher number of PD and CAL than NS.[29–31] Tobacco smoking is associated with an increase in advanced glycation end products (AGEs) and their receptors expression in oral epithelial cells, including gingival tissues, which exacerbates oxidative stress and inflammatory responses.[13,21]

Smokers are known to have a lower salivary flow rate and GCF compared to non-smokers. To confirm that condition, Plaque index (PI) will be useful parameter. PI is primarily associated with plaque control as well as adequate salivary and crevicular fluid flow. Variations in PI score may be due to differences in salivary and GCF flow rate between groups.[1,3,32]

This review confirm that CS has poorer PI compared to ES and NS.[13–15] Tatullo et al. (2016) demonstrated that when CS was switched the habits to ES, there was a consistent reduction of PI from baseline to T2 as the end of observational period, which found more pronounced in group ES2 who had a high PI score at T0.[1] In contrast, Wadia et al. (2016) found no difference when CS was replaced with ES.[16] In this case, different observational periods may affect the outcome. Wadia et al. (2016) observed the outcome after two weeks of switching[16] , whereas Tatullo et al. (2016) observed for 120 days.[1] The poorer level of PI found in smokers may be related to enhanced concentration of Ca^{2+} ion in saliva[32] and also initial increase of salivary secretion due to nicotine effect on exocrine glands[33] which prone to salivary mineralization.

There are a number of limitations to this study. First, three studies (table 3) included in the review were pilot studies or pilot investigations that could not accommodate a large number of participants. Second, each study included has its own definition of each group based on the duration or frequency of smoking. Third, quantitative analysis is not possible due to differences in methodology and clinical parameters assessed in the studies. Further research is needed to evaluate this theme, allowing the use of strict inclusion and exclusion criteria.

CONCLUSION

Within the scope of the current study, it is concluded that clinical periodontal health parameters are better in E-cigs smokers than in other smoker groups, and that E-cigs smokers may have periodontal status comparable to non-smokers besides BoP level. However, E-cigs should not be considered a risk-free alternative.

CONFLICT OF INTEREST

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