Dermatologic manifestations associated with electronic cigarette use

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Background: Electronic cigarette use continues to rise, yet there are no reviews summarizing dermatologic manifestations associated with electronic cigarettes in the literature.

Objective: To review the literature regarding cutaneous manifestations associated with electronic cigarette use and increase awareness of side effects associated with this rapidly developing public health epidemic.

Methods: The PubMed database was searched for related literature. All studies involving the effects of electronic cigarette use on the skin or mucosa were obtained and reviewed for evidence.

Results: Contact dermatitis, thermal injuries, and oral mucosal lesions have been reported with the use of electronic cigarettes.

Limitations: The conclusions presented in individual case reports or series are not based on randomized controlled trials.

Conclusion: Electronic cigarettes can present with harmful dermatologic manifestations. (J Am Acad Dermatol 2019;81:1001-7.)

Key words: burn injuries; contact dermatitis; electronic cigarettes; lichen planus; nicotine stomatitis; oral lesions.

Electronic nicotine delivery systems are devices that utilize thermal energy produced by a heating coil to vaporize a liquid, creating an aerosol that can be inhaled to mimic the effects of tobacco smoking. Electronic nicotine delivery systems can come in many varieties, including the popular electronic cigarette (e-cigarette) (Fig 1).[1] Commonly thought of as a safe and clean replacement during the process of quitting traditional tobacco smoking, e-cigarettes have now been demonstrated by the literature to be associated with an increased prevalence of dermatologic conditions. For example, Hua et al conducted a review of online e-cigarette forums in search of health effects and reported symptoms. Of the total of 481 e-cigarette users posting a symptom in the forums, 67 (13.9%) reported a dermatologic symptom, including dermatitis, burns, acne, boils, bumps, blisters, and various other symptoms.[2] In light of these findings, we conducted a review of the most current literature describing the dermatologic conditions associated with the use of e-cigarettes (Table I).[3-12]

EPIDEMIOLOGY

E-cigarettes were first introduced into the US market in 2007.[13] Since then, the use of e-cigarettes in the United States has skyrocketed. In 2010-2013, use e-cigarette among US adults increased from 3.3% to 8.5%.[13] In 2016, 3.2% of US adults were active e-cigarette consumers, and 15.4% had used an e-cigarette at least once.[14] This compares with the 15.5% of US adults who were current cigarette smokers in 2016.[15] Furthermore, a 2016 study

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showed that 2 million US middle and high school students reported the use of an e-cigarette device in the last 30 days, with 4.3% of the responses coming from middle school students and 11.3% coming from high school students.[15] Traditional cigarettes were used by only 8% of high school students and 2.2% of middle school students.[15]

As e-cigarettes do not contain carcinogens or tar, a common misconception is that they are safe to use. However, there is a rapidly growing body of literature questioning the safety of e-cigarettes. Current data suggest an association between e-cigarette use and harmful effects to the respiratory and cardiovascular system, leading to increased arterial stiffness, increased blood pressure, irregular heartbeats, lung inflammation, and an increased risk of cardiovascular disease, respiratory disease, and death.[16-19]

CAPSULE SUMMARY

- Use of electronic cigarettes is becoming increasingly prevalent, but there are few data summarizing the dermatologic effects associated with their use.
- Dermatologists should be more cognizant of electronic cigarette use when taking a social history of patients presenting with new oral lesions, contact dermatitis, or burn injuries.

CONTACT DERMATITIS

Over the last 3 years, an increase in the number of cases of contact dermatitis secondary to e-cigarette use has been reported. This is secondary to the release of nickel from e-cigarette devices. The source of nickel in an e-cigarette is the heating coil, which is used to vaporize the liquid into an aerosol for inhalation by the user.[20] The nickel is transmitted through the device, thus frequently irritating the dominant hand used to hold the e-cigarette.

Maridet et al reported the first case of contact dermatitis associated with e-cigarette use. With a known history of allergy to nickel, a woman developed a scaly, erythematous rash to her dominant hand after using an e-cigarette. Analysis of the patient's device demonstrated a positive reaction on a dimethylglyoxime (DMG) nickel spot test. Subsequently, their team analyzed multiple e-cigarette devices (11 in total), and found 4 devices testing positive on a DMG nickel spot test.[3] Ormerod and Stone reported a similar case involving an individual who also had a history of allergic reaction to nickel (belt buckles, costume jewelry). This patient had used an e-cigarette device for 2 to 3 months in an effort to stop smoking traditional cigarettes. She developed an erythematous, itching rash to her dominant hand. Erythema and swelling of the lips also developed.[4] Shim and Kosztyuova reported an additional 2 cases of contact dermatitis caused by nickel release from e-cigarette devices. Two patients had begun to use e-cigarettes in an effort to quit traditional cigarette smoking. Both patients demonstrated erythematous, scaly, and pruritic patches of the hands. One patient showed involvement of the face as well. Both devices were positive on a DMG nickel spot test, and the patches resolved with cessation of e-cigarette use.[5]

Therefore, clinicians should consider e-cigarettes in suspected cases of contact dermatitis in individuals with a confirmed allergy to nickel on patch testing.

THERMAL INJURY

Electronic cigarettes are commonly equipped with lithium-containing batteries that allow for long battery life and small packaging into the e-cigarette device. The use of lithium-containing batteries is associated with multiple inherent risks that were previously described by Brown and Cheng.[21] Poor product design, manufacturing failures, and use of low-quality materials in the production of the lithium-containing batteries used for e-cigarettes have led to a lack of internal thermal regulation in certain devices' battery component. With faulty internal thermal regulation, the battery can rise in temperature to such an extent that it results in a fire and/or explosion or rise to a temperature that induces contact thermal burns without actually catching fire. This cycle is known as thermal runaway, and it is the mechanism behind e-cigarette–related cutaneous injuries.[21]

Thermal runaway can lead to multiple different types of burn injuries sustained from e-cigarettes that are mentioned in the subsequent cases. Thermal injuries can be caused by devices that are in close contact with the skin while reaching excessive temperatures, with or without generating a flame, leading to cutaneous burns. Explosion injuries due to thermal runaway can also result in thermal injuries, and they have the added potential to expel the alkali chemical contents inside the lithium battery upon explosion, resulting in chemical burn injuries. Additionally, the explosion of an e-cigarette can lead to blast injuries, resulting in severe soft-tissue in addition to thermal injuries, tooth loss, and the need for more drastic surgical repair of tissue defects.[8]

Between 2015 and 2017, an estimated 2035 individuals with explosion and burn injuries from e-cigarettes presented to US emergency departments, which is more than 40 times the

Abbreviations used:

BHT:	black hairy tongue
DMG:	dimethylglyoxime
e-cigarette:	electronic cigarette
IL:	interleukin
OML:	oral mucosal lesion

number of injuries reported by the US Food and Drug Administration from 2009 to 2015.[22] As shown in Table I and Fig 2,[23] numerous body locations are involved in thermal injuries from e-cigarettes, including the hands, thighs, lower legs, head, and external genitals.

In the largest of the 4 case series presented in this review, Ramirez at al report on 30 cases of cutaneous burns experienced by patients from e-cigarette batteries. An explosion was identified in 26 of 30 cases (87%). Their case series demonstrated a mean burn size of 4% of the total body surface area, with the most common locations being the thighs, hands, and genitalia. Almost all patients (26 of 30) required hospital admission, and 9 patients required surgery as a result of their injuries. The devices causing injury in this case series were primarily being carried idle on personal attire at the time of explosion.[9]

Jiwani et al reported on 10 patients who sustained an injury attributed to e-cigarette batteries. Of those patients, 9 sustained a thermal injury and 1 sustained both a thermal and blast injury from e-cigarette explosion. Treatment varied according to depth and extent of the burn. Five patients were treated nonoperatively. The remaining 5 required surgical intervention, including surgical debridement or excision and split-thickness skin grafting.[6] Maraqa et al reported an additional 8 patients who sustained unspecified cutaneous burns related to explosion injuries from e-cigarette lithium-ion batteries. Of their 8 patients, 5 developed partial-thickness burns and 3 had full-thickness burns; 2 of their 8 patients required skin grafting.[7]

Another study by Brownson et al demonstrated 15 cases of e-cigarette explosion injuries due to the lithium-ion battery component. Of their patient cohort, 80% demonstrated thermal burn injuries, whereas 33% demonstrated chemical burn injuries. Uniquely, they noted that their 15 case patients presented during the period from October 2015 through June 2016. In contrast, 25 patients involved in such incidents presented during the period of 2009 through 2014.[8] Their comparison demonstrates a sharp uptick in the number of incidents of thermal injury related to the e-cigarette thermal runaway phenomenon.

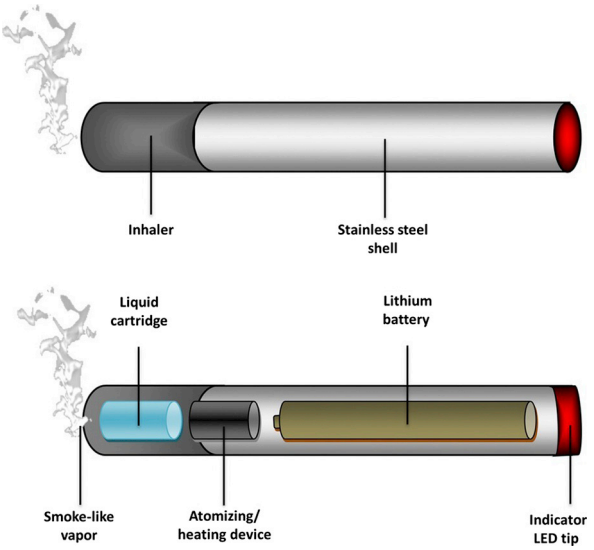

Fig 1. Electronic cigarette design. Depicted is the standard electronic cigarette design. *LED*, Light-emitting diode. (Reproduced with permission from Rom et al.[1])

ORAL LESIONS

Oral mucosal lesions (OMLs) have long been shown to be associated with tobacco smoking.[24] The current literature does not demonstrate a reduced risk in the development of OMLs by switching from traditional cigarettes to e-cigarettes. In fact, an increased prevalence of OMLs has been demonstrated in e-cigarette users.[10] For example, Bardellini et al demonstrated a higher percentage of OMLs in e-cigarette users, with 3 individual types of inflammatory lesions in the oral cavity being more prevalent than in former smokers: nicotine stomatitis, hyperplastic candidiasis, and black hairy tongue (BHT).[10] Each of these oral mucosal conditions is discussed in the following sections, as is a case of an oral lichenoid reaction associated with e-cigarette use. Importantly, the cohort of Bardellini et al and the individual case patients of OMLs discussed in the following sections comprise former traditional cigarette users who began using e-cigarettes after quitting. Although there was no mention of a history of OMLs during use of traditional cigarettes by the individuals discussed in these articles, the lack of an explicit statement saying that there was no history of OMLs calls into question the validity of the prevalence of OMLs in e-cigarette users compared with in former smokers and/or active traditional cigarette users.

Nicotine stomatitis

Nicotine stomatitis, also known as stomatitis nicotina or smoker's keratosis, is an irritating

Table I. Studies demonstrating dermatologic manifestations due to e-cigarette use

Condition	Cases, n	Location/demographic	Year	Reference
Contact dermatitis	1	Dominant hand	2015	3
	1	Dominant hand, lips	2017	4
	2	Bilateral hands	2018	5
Thermal injury	10	Left thigh (5) Right thigh (3) Scrotum (1) Left arm/hand (2) Right arm/hand (3) Head (1) Chest (1) Males (9) (age range, 19-46 y) Females (1) (age, 18 y)	2017	6
	8	Left thigh (4) Right thigh (2) Scrotum (2) Left hand/arm (2) Right hand/arm (1) Left lower extremity (2) Right lower extremity (1) Chest (1) Males (8) (age range, 17-47 y)	2018	7
	15	Face (3) Hands (5) Thigh or groin (8)	2016	8
	30	Thigh, hands, genitalia* Males (NM) Females (NM)	2017	9
Nicotine stomatitis	6	NM	2017	10
Black hairy tongue	7	NM	2017	10
	1	Female	2015	11
Hyperplastic candidiasis	8	NM	2017	10
Oral lichenoid reaction	1	Male (age, 55 y)	2016	12
Oral cancer	2	Males (2) (ages, 59 and 66 y)	2017	1

NM, Not mentioned.
*No specific mention of the exact number of injuries at each anatomic site.

condition of the oral mucosa. Clinical presentation involves diffuse gray or white color change to the hard palate that may progress to interspersed mucosal thickening and fissuring demonstrating the classic "cracked mud" appearance associated with this condition (Fig 3).[24,25] Bardellini et al found a statistically significant increased prevalence of nicotine stomatitis in e-cigarette users compared with in former smokers.[10] Exposure of the palatal mucosa to nicotine or chemical compounds introduced into the liquid to add flavor may be an etiologic factor. However, this speculation differs from previous theories, suggesting that that nicotine stomatitis is the result of high amounts of heat being concentrated in the mouth from smoking or consuming extremely hot beverages, rather than the nicotine itself.[24,26] Thus, further investigation is needed to clarify this pathophysiology.

Hyperplastic candidiasis

Hyperplastic candidiasis is caused by an overgrowth of *Candida* species in the oral cavity, most commonly *Candida albicans*. It historically presents as white patches on the oral mucosal commissures and is associated with a wide spectrum of risk factors, including diabetes mellitus and immunosuppression.[27] In a comparison of e-cigarette consumers with former smokers, Bardellini et al discovered a statistically significant increased prevalence of hyperplastic candidiasis in e-cigarette consumers.[10] It was noted that although the presence of hyperplastic candidiasis has been demonstrated in smokers before, there have been no data about e-cigarette consumers. Bardellini et al presumed that the increase in hyperplastic candidiasis could be due to a favorable pH alteration induced by chemical compounds used for the flavoring of e-cigarettes.[10]

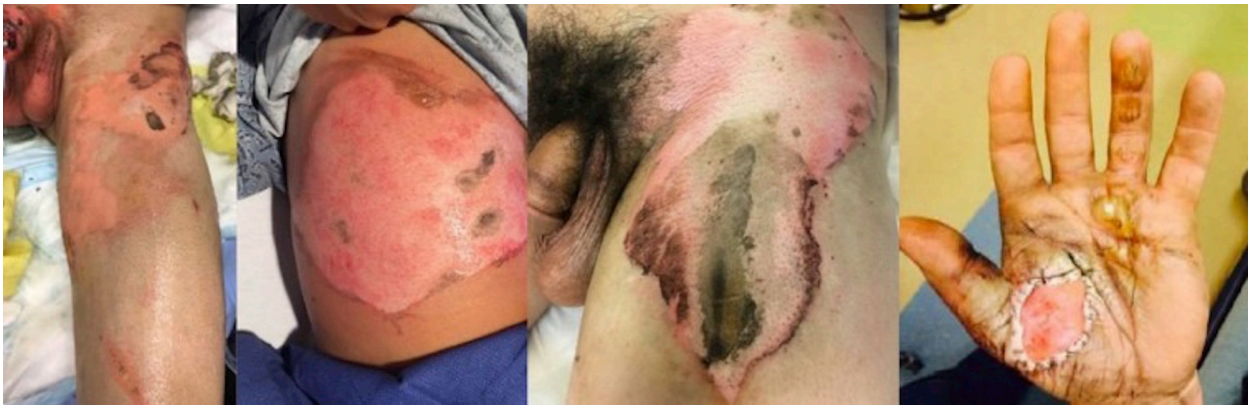

Fig 2. Thermal burn injuries. Images from separate patients who experienced thermal burns related to electronic cigarettes. (Reprinted with permission from Elsevier from Hickey et al.[23])

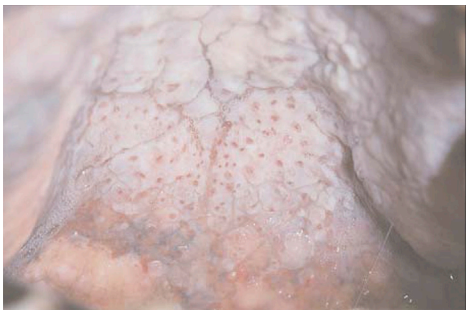

Fig 3. Nicotine stomatitis. Nicotine stomatitis in an individual who was a heavy pipe tobacco smoker. (Reproduced with permission from Neville and Day.[25])

Oral lichenoid reaction

Oral lichen planus commonly presents with radiating white-gray papules forming a fine, lacy, reticular pattern known as Wickham striae.[28] Allergic oral lichenoid reactions do likewise, making it difficult to clinically distinguish them from oral lichen planus.[29] Bartram et al reported the first known patient to develop an allergic oral lichenoid reaction following e-cigarette use. The patient presented with an 8-week history of right buccal mucosa ulceration and coinciding 8-week history of e-cigarette use. Physical examination demonstrated a white reticular patterned striae on the oral mucosa and lower lip, with biopsy confirming a florid lichenoid reaction (hyperkeratosis with lichenoid inflammation). After the individual switched from a high-concentration propylene glycol brand of e-cigarette to a lower—propylene glycol concentration brand, there was mild persistence in 1 location on the lower lip but resolution of all other oral lichenoid lesions.[12] As the treatment that led to resolution was lowering propylene glycol levels, one could pinpoint propylene glycol as the causative agent in e-cigarettes that led to this oral lichenoid reaction. However, patch testing was not performed to confirm this potential allergic reaction. Although propylene glycol is used as an effective vehicle for topical preparations, its use has not been without significant adverse cutaneous effects. Propylene glycol has been linked to allergic contact dermatitis and irritating effects of the skin, especially in high doses. Although unconfirmed, exposure to a contact allergen has been suspected to be a factor contributing to the lichen planus eruption.[30] Thus, it could be suggested that propylene glycol exposure in e-cigarette use initiated an aberrant immune response, which in turn initiated a lichenoid eruption. Interestingly, Bardellini et al did not find statistical significance in the prevalence of lichen planus in e-cigarette consumers versus in formers smokers.[10] Two of the former smokers demonstrated lichen planus, whereas no e-cigarette consumers demonstrated the condition.

BHT

BHT, or lingua villosa nigra, is a benign, asymptomatic condition that involves 2 pathologic components: elongation of filiform papillae secondary to lack of desquamation on the dorsal aspect of the tongue and discoloration of the tongue as a result of an altered oral environment, leading to the growth of porphyrin-producing chromogenic bacteria or yeast.[31] Multiple risk factors for BHT have been established. One study found a particularly prevalent association with tobacco use in older adult males.[32] Here, we discuss a case of BHT associated with e-cigarette use.

Farinha and Martins reported a case of BHT in an e-cigarette smoker who had recently switched from traditional cigarettes in an effort to quit smoking. After using an e-cigarette for 2 weeks, the patient developed an asymptomatic black discoloration of

her tongue. After a diagnosis of BHT was made, the patient stopped using the e-cigarette and began using a tobacco cigarette. This resulted in spontaneous resolution of her discoloration. Interestingly, when she began using her e-cigarette again, the discoloration re-emerged.[11]

In line with the findings of Farinha and Martins,[11] Bardellini et al demonstrated a statistically significant greater prevalence of BHT in e-cigarette consumers than in former smokers.[10] The group speculated that this higher prevalence may be due to smoking-associated pH changes, mucosal drying effects, high intraoral temperatures, local alteration of membrane barriers and immune responses, or altered resistance to fungal and viral infections. Therefore, clinicians should consider obtaining a thorough social history when encountering BHT.

CONCLUSION

Tobacco cigarette smoking has historically been linked to dermatologic conditions, including oral leukoplakia, psoriasis, hidradenitis suppurativa, cutaneous squamous cell carcinoma, oral candidiasis, lingua villosa nigra, acne, and alopecia.[33-39] Although a common misconception is that e-cigarettes are a safe alternative because of the lack of carcinogens and tar in e-cigarette liquid, there is early evidence that they are also harmful to human skin. Exposure to e-cigarette smoke has been shown to reduce cell viability, change ultrastructure, and induce the release of proinflammatory cytokines (interleukin 6 [IL-6], IL-8, and IL-10) in human keratinocytes.[40] Additionally, the negative impact of e-cigarettes on neutrophil function has been speculated to play a negative role in psoriasis and other systemic conditions.[41]

With these cytologic effects in mind, the association between e-cigarettes and the multiple skin-related conditions outlined in this review suggest that e-cigarettes are not safe alternatives to traditional tobacco cigarettes in terms of development of dermatologic issues. As the use of e-cigarettes continues long-term and the number of users rises, additional studies should investigate the dermatologic manifestations of e-cigarette consumption.

REFERENCES

1. Rom O, Pecorelli A, Valacchi G, Reznick AZ. Are e-cigarettes a safe and good alternative to cigarette smoking? *Ann N Y Acad Sci*. 2015;1340:65-74.
2. Hua M, Alfi M, Talbot P. Health-related effects reported by electronic cigarette users in online forums. *J Med Internet Res*. 2013;15:e59.
3. Maridet C, Atge B, Amici JM, Taïeb A, Milpied B. The electronic cigarette: the new source of nickel contact allergy of the 21st century? *Contact Dermatitis*. 2015;73:49-50.
4. Ormerod E, Stone N. Contact allergy and electronic cigarettes (and eyelash curlers). *Clin Exp Dermatol*. 2017;42:682-683.
5. Shim TN, Kosztyuova T. Allergic contact dermatitis to electronic cigarette. *Dermatitis*. 2018;29:94-95.
6. Jiwani AZ, Williams JF, Rizzo JA, Chung KK, King BT, Cancio LC. Thermal injury patterns associated with electronic cigarettes. *Int J Burns Trauma*. 2017;7:1-5.
7. Maraqa T, Mohamed MAT, Salib M, Morris S, Mercer L, Sachwani-Daswani GR. Too hot for your pocket! Burns from e-cigarette lithium battery explosions: a case series. *J Burn Care Res*. 2018;39:1043-1047.
8. Brownson EG, Thompson CM, Goldsberry S, et al. Explosion injuries from e-cigarettes. *N Engl J Med*. 2016;375:1400-1402.
9. Ramirez JI, Ridgway CA, Lee JG, et al. The unrecognized epidemic of electronic cigarette burns. *J Burn Care Res*. 2017;38:220-224.
10. Bardellini E, Amadori F, Conti G, Majorana A. Oral mucosal lesions in electronic cigarettes consumers versus former smokers. *Acta Odontol Scand*. 2018;76:226-228.
11. Farinha H, Martins V. Lingua villosa nigra associated with the use of electronic cigarette. *Acta Med Port*. 2015;28:393.
12. Bartram A, Jones N, Endersby S. Lichenoid eruption associated with use of an e-cigarette. *Br J Oral Maxillofac Surg*. 2016;54:475.
13. King BA, Patel R, Nguyen KH, Dube SR. Trends in awareness and use of electronic cigarettes among US adults, 2010-2013. *Nicotine Tob Res*. 2015;17:219-227.
14. Schoenborn C. QuickStats: percentage* of adults who ever used an e-cigarette† and percentage who currently use e-cigarettes,§ by age group—National Health Interview Survey, United States, 2016¶. *MMWR Morb Mortal Wkly Rep*. 2017;66:892.
15. Jamal A, Gentzke A, Hu SS, et al. Tobacco use among middle and high school students—United States, 2011-2016. *MMWR Morb Mortal Wkly Rep*. 2017;66:597-603.
16. Vlachopoulos C, Ioakeimidis N, Abdelrasoul M, et al. Electronic cigarette smoking increases aortic stiffness and blood pressure in young smokers. *J Am Coll Cardiol*. 2016;67:2802-2803.
17. Grana R, Benowitz N, Glantz SA. E-cigarettes: a scientific review. *Circulation*. 2014;129:1972-1986.
18. Zhang G, Wang Z, Zhang K, et al. Safety assessment of electronic cigarettes and their relationship with cardiovascular disease. *Int J Environ Res Public Health*. 2018;15.
19. Qasim H, Karim ZA, Rivera JO, Khasawneh FT, Alshbool FZ. Impact of electronic cigarettes on the cardiovascular system. *J Am Heart Assoc*. 2017;6.
20. Olmedo P, Goessler W, Tanda S, et al. Metal concentrations in e-cigarette liquid and aerosol samples: the contribution of metallic coils. *Environ Health Perspect*. 2018;126:027010.
21. Brown CJ, Cheng JM. Electronic cigarettes: product characterisation and design considerations. *Tob Control*. 2014;23(Suppl 2):ii4-ii10.
22. Rossheim ME, Livingston MD, Soule EK, Zeraye HA, Thombs DL. Electronic cigarette explosion and burn injuries, US Emergency Departments 2015-2017. Tob Control https://doi.org/10.1136/tobaccocontrol-2018-054518. accessed.
23. Hickey S, Goverman J, Friedstat J, Sheridan R, Schulz J. Thermal injuries from exploding electronic cigarettes. *Burns*. 2018;44:1294-1301.
24. Taybos G. Oral changes associated with tobacco use. *Am J Med Sci*. 2003;326:179-182.
25. Neville BW, Day TA. Oral cancer and precancerous lesions. *CA Cancer J Clin*. 2002;52:195-215.

26. Rossie KM, Guggenheimer J. Thermally induced 'nicotine' stomatitis. A case report. *Oral Surg Oral Med Oral Pathol*. 1990;70:597-599.
27. Williams D, Lewis M. Pathogenesis and treatment of oral candidosis. *J Oral Microbiol*. 2011;3.
28. Wilder EG, Frieder J, Sulhan S, et al. Spectrum of orocutaneous disease associations: genodermatoses and inflammatory conditions. *J Am Acad Dermatol*. 2017;77:809-830.
29. Do Prado RF, Marocchio LS, Felipini RC. Oral lichen planus versus oral lichenoid reaction: difficulties in the diagnosis. *Indian J Dent Res*. 2009;20:361-364.
30. Roopashree MR, Gondhalekar RV, Shashikanth MC, George J, Thippeswamy SH, Shukla A. Pathogenesis of oral lichen planus--a review. *J Oral Pathol Med*. 2010;39:729-734.
31. Schlager E, St Claire C, Ashack K, Khachemoune A. Black Hairy Tongue: predisposing Factors, Diagnosis, and Treatment. *Am J Clin Dermatol*. 2017;18:563-569.
32. Avcu N, Kanli A. The prevalence of tongue lesions in 5150 Turkish dental outpatients. *Oral Dis*. 2003;9:188-195.
33. Bánóczy J, Gintner Z, Dombi C. Tobacco use and oral leukoplakia. *J Dent Educ*. 2001;65:322-327.
34. Naldi L. Psoriasis and smoking: links and risks. *Psoriasis (Auckl)*. 2016;6:65-71.
35. König A, Lehmann C, Rompel R, Happle R. Cigarette smoking as a triggering factor of hidradenitis suppurativa. *Dermatology*. 1999;198:261-264.
36. McBride P, Olsen CM, Green AC. Tobacco smoking and cutaneous squamous cell carcinoma: a 16-year longitudinal population-based study. *Cancer Epidemiol Biomarkers Prev*. 2011;20:1778-1783.
37. Soysa NS, Ellepola AN. The impact of cigarette/tobacco smoking on oral candidosis: an overview. *Oral Dis*. 2005;11:268-273.
38. Capitanio B, Sinagra JL, Ottaviani M, Bordignon V, Amantea A, Picardo M. Acne and smoking. *Dermatoendocrinol*. 2009;1:129-135.
39. Su LH, Chen TH. Association of androgenetic alopecia with smoking and its prevalence among Asian men: a community-based survey. *Arch Dermatol*. 2007;143:1401-1406.
40. Cervellati F, Muresan XM, Sticozzi C, et al. Comparative effects between electronic and cigarette smoke in human keratinocytes and epithelial lung cells. *Toxicol In Vitro*. 2014;28:999-1005.
41. Reidel B, Radicioni G, Clapp PW, et al. E-cigarette use causes a unique innate immune response in the lung, involving increased neutrophilic activation and altered mucin secretion. *Am J Respir Crit Care Med*. 2018;197:492-501.