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## The Impact of E-Cigarettes on Oral Injuries and Bone Fractures

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## **Abstract**

### **Introduction**

The rising prevalence of electronic cigarette (e-cigarette) use has prompted concerns regarding its potential health implications. While much attention has focused on respiratory and cardiovascular effects, injuries, oral trauma, and bone fractures linked to e-cigarette use have received less scrutiny. This paper aims to comprehensively review the landscape of injuries,

oral trauma, and bone fractures induced by e-cigarettes, shedding light on this underexplored facet of e-cigarette-related harm.

## **Material and Methods**

This literature review has analyzed 16 papers. Inclusion criteria: researches and case reports published after 2015. PubMed and Google Scholar has been searched to identify the papers.

### **Analysis of the Literature**

Existing literature suggests a growing incidence of injuries, oral trauma, and bone fractures associated with e-cigarette use, albeit with limited systematic investigation. Mechanisms underlying these injuries range from device malfunctions to inadvertent impacts during use. Case reports highlight a spectrum of injuries, including oral burns, dental trauma, and skeletal fractures, often involving the face and mouth regions.

### **Conclusions**

Despite the lack of comprehensive epidemiological data emerging evidence underscores the need for heightened awareness and preventive measures to mitigate e-cigarette-related injuries. Enhanced education, regulation of e-cigarette devices, and promotion of safer usage practices are crucial steps towards reducing the burden of e-cigarette-related harm on oral and skeletal health.

**Keywords** E-cigarettes, oral injury, bone fracture, burns

## **Introduction and purpose**

In recent years, the use of electronic cigarettes (e-cigarettes) has surged globally, presenting a paradigm shift in smoking habits. Marketed as a safer alternative to traditional tobacco products, e- cigarettes have garnered widespread popularity, particularly among adolescents and young adults. Despite the perception of reduced harm associated with their use, emerging evidence has shed light on the potential health risks and adverse consequences posed by e-cigarette devices [18, 23, 24].

Among the myriad of health concerns, injuries, trauma, and bone fractures have emerged as notable yet underrecognized complications linked to e-cigarette use. While the focus has predominantly been on respiratory and cardiovascular effects, the impact of e-cigarettes on orthopedic health remains a subject of growing interest and concern [19, 20].

This paper aims to provide a comprehensive examination of injuries, trauma, and bone fractures attributed to e-cigarette usage. By synthesizing existing literature and clinical data, we seek to elucidate the mechanisms underlying these injuries, characterize affected demographics, and explore potential preventive strategies and management approaches.

Understanding the spectrum of injuries associated with e-cigarettes is paramount for healthcare providers, public health officials, and policymakers alike. By shedding light on this underexplored facet of e-cigarette-related harm, we aim to contribute to the growing body of knowledge surrounding e-cigarette use and inform evidence-based interventions aimed at mitigating its adverse health effects.

### **Material and Methods**

This literature review has analyzed 16 papers. Inclusion criteria: researches and case reports published after 2015. PubMed and Google Scholar has been searched to identify the papers.

### **Analysis of the Literature**

#### **Ocular injuries and electronic nicotine delivery systems**

Poison control centers in the USA received reports of 1,393 incidents of ocular exposure associated with electronic nicotine delivery systems (ENDS). The number of cases escalated from two in 2010 to a peak of 389 in 2014, followed by a gradual decline from 2015 to 2018. Among these cases, 42.5% involved individuals aged 25 years and older, while 20.4% and 17.7% were among young adults aged 18–24 years and children under five years, respectively. Nearly one quarter (23.8%) of those affected sought or were advised to seek medical attention. A review of case narratives found that 59 out of 127 (46.5%) cases were attributed, to improper use or mishandling of the products. A significant portion of these incidents implicated young children, with nearly half attributed, at least partially, to improper use or mishandling of the products. To mitigate future occurrences, efforts may be directed towards enhancing awareness regarding the potential risks associated with ENDS products and emphasizing the importance of proper handling. Health care providers could play a pivotal role in educating patients and enhancing surveillance of ocular exposure cases related to ENDS [2, 30].

Another study reveals series detailing patients who experienced corneal injuries due to E-cigarettes (EC) explosions. Bilateral corneal burns and reduced visual acuity were observed, with one patient also suffering from a unilateral corneoscleral laceration accompanied by prolapsed iris tissue and hyphema. Various media outlets and government agencies have documented fires and explosions associated with ECs, including at least four cases involving ocular injuries. Users should be cautioned about the potential for serious harm, including ocular injuries that could endanger vision, such as corneal burns or full-thickness corneoscleral lacerations[12].

### **E-cigarettes explosions can lead to severe maxillofacial fractures and pneumocephalus**

A study conducted at the Arrowhead Regional Medical Center reported a case of a 59-year-old man assessed for trauma subsequent to an e-cigarette explosion incident during vaping. His physical examination revealed noticeable swelling and bruising around the right eye, tenderness in the upper jaw, and visible blood in the throat without active bleeding, along with a circular tear in the area between the nose and upper lip (philtrum). Additionally, he exhibited soot residue on his lips, right hand, and the right side of his face. Computed tomography (CT) imaging displayed fractures in various facial bones including the petrous, ethmoid, cribriform plate, nasal passages, nasal septum, and the right inner wall of the eye socket, as well as air trapped within the cranial cavity (pneumocephalus). Furthermore, he suffered a bruise around the right eye. The philtrum was almost completely detached, creating openings both inside the mouth and through the nasal lining, exposing the cartilage of the nasal septum [3].

Similar case was observed in another study, where a 20-year-old male experienced facial trauma on the right side when an e-cigarette detonated in his hand. The physical examination revealed a 1.5- cm depressed soft-tissue defect on the right nasal bone. Computed tomography (CT) scan showed a severely shattered fracture involving the right naso-orbital-ethmoid complex, with fractured segments displaced posteriorly from the frontal sinus's anterior table and the maxilla's frontal process. Additionally, there was a comminuted fracture in the posterior table, obstruction of the frontal sinus outflow tract , and a small region of pneumocephalus [4].

Another patient, previously healthy 19-year-old male, was transferred to the regional Major Trauma Centre from a local trauma unit following an unexpected explosion of the e-cigarette he was using, resulting in injuries. Upon arrival at his local trauma unit, it was evident that he had sustained significant injuries to both the hard and soft tissues of his oral cavity, particularly

affecting the anterior left maxilla. However, he was able to maintain his airway, and his vital signs were within normal limits. Additionally, he exhibited epidermal burns on the surrounding face, including the lips and upper chest. Surprisingly, despite this, the damage to his upper lip was minimal, albeit with noticeable swelling (oedema). Given the patient's presentation with signs suggestive of inhalation injury (such as a hoarse voice, burns to the face and oral cavity, and carbon deposits in his mouth), he underwent intubation, and intravenous fluids were initiated. Subsequent examination was conducted to assess for potential hidden burns[13, 21]. A following case describes a 27-year-old male who experienced an explosion of an electronic cigarette while using it, causing the mouthpiece to penetrate the pharynx and lodge into the first cervical vertebra, resulting in fractures of the first and second vertebrae. X-ray imaging of the neck revealed a foreign object at the level of C1, while a computed tomography scan confirmed fractures of C1. Emergency physicians need to be mindful of the potential hazards posed by electronic cigarettes and should maintain a low threshold for ordering radiographic examinations and seeking surgical advice in instances of electronic cigarette explosions within the oral cavity. With the continued rise in electronic cigarette usage, it is probable that associated injuries will also escalate [15].

### **Exploding e-cigarettes causing trauma in oral cavity**

Injuries comprise intraoral burns, luxation injuries, and fractures of the alveolar region[9]. A study performed at the University of Rochester Medical Center describes a case of an 18-year-old male who experienced burns to the oral and abdominal regions, along with lacerations in the oral cavity, tooth fractures and tooth avulsion resulting from an explosion of an E-cigarette while it was in his mouth. Clinical assessment revealed swelling of both upper and lower lips, with a hematoma present on the lower right lip. Additionally, a 1.0-cm-diameter laceration was identified at the vermilion border of the lower lip, along with a 3- × 1.5-cm laceration on the upper labial mucosa. Dental injuries included complete intrusion of the right lateral incisor, avulsion of the right central incisor, and a gingival-level fracture of the left central incisor. The right lateral incisor displayed a minor enamel fracture without dentin sensitivity. Gingival soft tissue injury was also noted, accompanied by a 2.0 cm laceration in the palatal tissue between the central incisors. Additional findings comprised midpalatal partial tissue avulsion, moderate ecchymosis at the apex of the hard palate, and soft tissue ulceration

to the left of the soft palate midline. Notably, there were no injuries detected in the tongue or posterior oropharynx [5].

A cross-sectional Korean research among high school students admitted that regarding electronic cigarette (EC) usage, 0.5% (n = 297) of students were daily EC users, 1.9% (n = 1259) were EC users for 1 to 29 days in the past month, and 5.9% (n = 3848) were former EC users in the past month. The vast majority, 91.8% (n = 60124), had never used ECs. Regarding the age at first EC use, among those who had ever used ECs, 2.9% (n = 159) had their first experience before 1st grade, and 7.5% (n = 401) had their first experience between 1st and 6th grade. Regarding the primary reason for EC use, 'to use ECs indoors' was the most commonly cited reason among daily EC users. According to the findings, the likelihood of experiencing cracked or broken teeth was notably elevated among daily, '1 to 29 days past month', and former EC users compared to those who had never used ECs. Similarly, the probability of tongue and/or inside-cheek pain was significantly higher among daily EC users compared to those who had never used ECs. In summary, these results indicate that daily EC usage among adolescents could pose a risk factor for cracked or broken teeth as well as tongue and/or inside-cheek pain [11].

### **US children's vaping trauma experience**

Fifteen children from the multi center American study experienced traumatic injuries resulting from an E-cigarette explosion. Their median age was 17 years, ranging from 13 to 18. The median injury severity score was 2, with a range of 1 to 5. Among them, three patients noted that their injury occurred during their first vaping experience. Ten patients needed hospitalization, with three of them requiring admission to the intensive care unit. The hospitalized patients had a median length of stay of 3 days, ranging from 1 to 6. The injuries sustained included facial burns (6 cases), loss of multiple teeth (5 cases), thigh and groin burns (5 cases), hand burns (4 cases), ocular burns (4 cases), a radial nerve injury, a facial laceration, and a mandible fracture. Six children underwent surgical intervention, with one requiring multiple operations for a severe hand injury. Besides vaping-related lung injury, there's an emerging and concerning trend of vaping-related traumatic injuries among adolescents in the United States. This report underscores another way in which e- cigarettes are posing a growing risk to a vulnerable youth population [6].

## Classification of burn injuries

A study conducted at The Acute Care Surgery Service – University of South Alabama, treated two patients following e-cigarette burns. One patient suffered thigh and penis injuries, necessitating surgical intervention after the device ignited in his pocket. The second patient sustained facial burns and corneal abrasions when the device exploded while inhaling vapor. A search on the internet and examination of case studies yielded 26 cases for assessment. The burn patterns were categorized into direct injuries resulting from the device igniting and indirect injuries caused by house or car fires. A numerical classification system was devised: direct injury - type 1 (hand injury) with 7 cases, type 2 (face injury) with 8 cases, type 3 (waist/groin injury) with 11 cases, and type 5a (inhalation injury from device use) with 2 cases; indirect injury - type 4 (house fire injury) with 7 cases and type 5b (inhalation injury from fire ignited by the device) with 4 cases [7].

The categorization of injuries related to explosions from Electronic Nicotine Delivery Systems (ENDS), as suggested by Patterson [7]:

Type I - Hand Injury Type II - Face Injury

Type III - Waist/groin injury

Type IV - Injuries due to house fire ignited by ENDS Type Va - Direct upper airway inhalation injury

Type Vb - Subglottic inhalation injury

Other study revealed that men were significantly more affected by injuries resulting from ENDS (Electronic Nicotine Delivery Systems) explosions. All patients included in the study presented with at least partial-thickness burns. Additionally, 39 patients (85%) experienced deep partial-thickness burn injuries, while eight patients (17%) exhibited full-thickness burns. In total, 32 patients (69%) sustained injuries to the waist and groin region, with 12 patients (25%) experiencing hand injuries and three patients (7%) sustaining facial injuries. Regarding the Patterson classification, 25% of injuries were categorized as Type I, 7% as Type II, and 69% as Type III. No Type IV or Type V injuries were observed. The mean affected total body surface area (TBSA) was 3%. ENDS explosions result in a distinctive injury pattern, impacting the groin and thigh areas, hands, and face. Surgical intervention is frequently required for patients affected by these injuries. It is imperative to raise public awareness about the serious hazards



associated with ENDS explosions. Doing so serves a dual purpose: addressing the risk of explosions and harnessing the "dread-risk" effect, which could potentially lead to a cessation of ENDS misuse altogether [8, 26].

A retrospective chart review of the American Burn Association burn registry data was conducted across five major burn centers from January 2015 to July 2019 to identify patients with electronic cigarette-related injuries. A total of 127 patients were found. The majority of these patients sustained burns affecting less than 10% of their total body surface area, with a mean of 3.8%. Sixty-six percent suffered from second-degree burns. Most injuries (78%) occurred while patients were using their devices. Eighteen percent reported injuries resulting from spontaneous combustion of their devices. Two patients were injured while changing their device battery, and another two while modifying their device. Three percent experienced injuries due to secondhand mechanisms. Burn injury was the most prevalent type (100%), followed by blast injury (3.93%). Among thermal injuries, flame burns accounted for 70%, although many patients experienced a combination of burn mechanisms. Extremities were the most commonly injured body region. Silver sulfadiazine was frequently used in the initial management of thermal injuries. Surgery was required for 36% of patients, with 43.4% of them needing skin grafting. Instances of multiple surgeries were rare [10, 29].

During a one-year timeframe, Saint Louis Hospital Burn Center in Paris, France, attended to ten patients with injuries related to e-cigarette use. Among them, four required hospitalization, while the remaining six received treatment at the Outpatient Burn Clinic. All patients were male, with an average age of 39 years [range, 26-55]. The average extent of burn injuries covered 3% of the total body surface area (TBSA), ranging from 0.5% to 5%. Each patient experienced localized burns affecting at least one limb, with the most common areas being the thigh (80%) and the hand (50%) [16, 22].

### **The impact of E-cigarettes on mesenchymal stem cells**

It is crucial to examine the impact of E-cigarette use on mesenchymal stem cells (MSCs). MSCs, sourced primarily from bone marrow, play a key role in regulating bone turnover, especially during the healing process following injury. When cultured under osteogenic conditions, MSCs demonstrated decreased expression of alkaline phosphatase mRNA,

significantly reduced levels of type I collagen (COL1) mRNA expression, and diminished mineralization after exposure to E- cigarette smoke extract. The authors also observed a notable decrease in connexin43 protein expression. Connexin43 is involved in the formation of gap junctions, which are thought to contribute to the osteogenic differentiation of MSCs. Hence, the suppression of connexin43 expression may represent a potential mechanism through which E- cigarette use inhibits MSC commitment to the osteoblast lineage[17, 28].

### **Smoking is a risk factor of bone fracture**

Individuals who smoke face a heightened risk of fractures and encounter greater challenges with delayed bone healing, even after cessation, as certain adverse effects linger for an extended period. While some risks can be mitigated through preventive measures during and after surgery, smoking cessation remains a crucial factor in reducing these risks. However, implementing strategies to reduce tobacco use can be challenging for patients who aim to quit smoking at the time of a fracture. Moreover, patients should be cautioned that the use of e- cigarettes or other tobacco products does not seem to mitigate the adverse health effects associated with smoking. The evidence examined in this study indicates that smoking negatively impacts both the risk and treatment of fractures [14, 20, 27].

### **Conclusions**

In conclusion, our thorough examination emphasizes the critical necessity of addressing the range of injuries, oral trauma, and bone fractures associated with e-cigarette usage. Despite the ongoing promotion of e-cigarettes as safer alternatives to traditional tobacco products, their potential for harm extends beyond the respiratory and cardiovascular systems to impact oral and skeletal health. The evidence synthesized in this review underscores the diversity and severity of injuries linked to e-cigarette use, stressing the importance of increased awareness among healthcare professionals, policymakers, and the general populace.

Looking ahead, concerted efforts are essential to bridge the gaps in knowledge regarding e-cigarette-related injuries through expanded research and surveillance endeavors. This entails conducting comprehensive epidemiological studies to ascertain the true incidence and prevalence of these injuries, alongside investigations into the underlying mechanisms and risk determinants. Furthermore, targeted interventions are imperative to mitigate e-cigarette-related

harm, including educational initiatives, regulatory measures aimed at bolstering device safety, and advocacy for safer usage practices.

Addressing injuries, oral trauma, and bone fractures induced by e-cigarettes comprehensively enables us to safeguard public health and develop evidence-based strategies to minimize the adverse impacts of e-cigarette use. Collaboration among stakeholders across healthcare, public health, and regulatory sectors is crucial to effectively tackle this emerging public health challenge. Only through unified action can we alleviate the mounting burden of e-cigarette-related injuries and ensure the well-being of individuals worldwide.

## Disclosures

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Conceptualization: Karen Głogowska, Mikołaj Wojtas; Methodology: Wojciech Kopacz, Marcin Kapica; Formal analysis: Aleksandra Żmijewska, Mateusz Sztybór; Investigation: Maria Krzyżanowska, Monika Maleszewska; Writing - rough preparation: Julia Piątkiewicz, Gabriela Nowak; Writing - review and editing: Karen Głogowska, Mikołaj Wojtas; Supervision: Mikołaj Wojtas, Karen Głogowska. All authors have read and agreed with the published version of the manuscript.

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