Electronic cigarette devices and oro-facial trauma (Literature review)

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Abstract. Detrimental effects of cigarette smoking have been well described and recognized globally. With recent advancement of technology, electronic cigarette has been introduced and gained its popularity and became a global trend, especially among young adults. However, the safety of the electronic devices remains debatable. This paper aimed to compile and review the reported cases of oro-facial trauma related to the usage of electronic cigarette devices. A literature search was conducted using PubMed/Medline in December 2016. The search terms used were a combination of “oral trauma”, “dental trauma”, “oral injury” and “electronic cigarette”. The search included all abstract published from the inception of the database until December 2016. Abstract that was written in English, case report, letter to editors, clinical and human studies were included for analysis. All selected abstract were searched for full articles. A total of 8 articles were included for review. All of the articles were published in 2016 with mostly case reports. The sample size of the studies ranged from 1 to 15 patients. Seven of the included articles are from United States of America and one from Mexico. Our review concluded that the use of electronic cigarette devices posed not only a safety concern but also that the devices were mostly unregulated. There should be a recognized authority body to regulate the safety and standard of the electronic devices.

1. Introduction
With billions of smokers worldwide, smoking addiction and its detrimental effect on human health have been a major concern of every health care professional. To date, it has been agreed that cigarette smoking causes harmful effects towards human beings which can be fatal [1]. On the other hand, electronic cigarette (e-cigarette) has gained its popularity across the globe. It made its first debut in 2003 and has been available in the United States since then [2]. This electronic device, mimicking the traditional cigarette, is battery-powered which heated and vaporized nicotine-propylene glycol solution, creating a mist [3].

Moreover, the safety of the electronic device is also questionable as it can generate high temperature which may lead to explosion and fire [2]. It was reported that 80% of explosion cases happened while charging, where there are multiple choices of charging source such as USB port, USB adapter, and desktop computer USB [4]. Besides, the use of e-cigarette becomes questionable since users often connect the device to power adapter which are not provided by manufacturer. Furthermore, lithium-ion batteries have the characteristic of flammable electrolyte that will lead to fire and explosion whenever overheating happens. There is an ongoing development of non-flammable electrolyte for lithium-ion but the availability is yet to be announced [4]. This paper will discuss on the
safety of e-cigarette devices and compile the reported cases of oro-facial trauma secondary to the use of the devices.

2. Materials and Methods
A literature search was carried out using PubMed/Medline in December 2016. The terms used were a combination of “oral trauma”, “dental trauma”, “oral injury” and “electronic cigarette”. The search included all studies published from the date of inception of the database until December 2016. The inclusion criteria are: English language, clinical study, case report, letter to editor and human study that involved electronic cigarette devices. The exclusion criteria are: in-vitro study, laboratory study, review article and animal study. All selected abstract were search for full articles. For abstracts that were doubtful or with insufficient information, full articles were searched and the decision was made based on the inclusion and exclusion criteria. A manual search was also performed from the reference list of the included articles in order to identify any missing studies that were not included in the database search.

3. Results and Discussion

3.1 Results
After the selection process, 8 articles were qualified for final analysis. All of the articles were published in 2016. Case study was most frequently reported. The sample size of the included studies ranged from 1 to 15 subjects. Seven of the included articles are from United States of America and one from Mexico. Table 1 showed the summary of included articles.

| Year | Author | Type of Study | Initiation | Oro-facial injuries | Country |
|------|--------|--------------|------------|---------------------|---------|
| 2016 | Rog, J. M. [2] | Case Report | • While activating the device by pushing the buttons | • Oral burns<br>• Oral lacerations – vermillion border of lower lip, upper labial mucosa.<br>• Tooth fracture (no 9), enamel fracture (no 10)<br>• Tooth avulsion (no 8), intruded (no 7)<br>• Swelling of upper and lower lips and hematoma on right lower lip | United States of America |
| 2016 | Cason, Morgan, Letter to Editor & Pietryga [5] | Lithium-ion batteries | • Improperly insulated lithium ion battery<br>• Exposure to volatile liquids | • Injuries and burns to face<br>• Comminuted fractures of his hard palate and nasal septum, dislocation of adjacent teeth<br>• Defect in soft palate, possible of oro-antral fistula | United States of America |
| 2016 | Archambeau et al. [6] | Case Report | • Improperly insulated lithium ion battery<br>• Exposure to volatile liquids | • Maxillary tenderness<br>• Gross blood in the oropharynx without brisk bleeding<br>• Circular avulsion injury to the philtrum | United States of America |
| Year | Author                  | Type of Study    | Initiation                                                                                                                                                                                                 | Oro-facial injuries                                                                                                                                                                                                 | Country                        |
|------|-------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 2016 | Norii & Plate [7]       | Case report      | • After replacement with new lithium-ion battery                                                                                                                                                    | • Fractures of the petrous, ethmoid, cribiform plate, nasal choanae, nasal septum, right medial orbital and pneumocephalus  
• Nearly completely avulsed philtrum communicated intraorally and through the nasal mucosa bilaterally with exposure of nasal septal cartilage.  
• Partial thickness burns to his lips and an abrasion on his tongue and fracture of his bilateral upper incisor.  
• Limited jaw mobility.  
• Puncture wound in the posterior oropharynx.  
• Foreign body in the neck at the level of C1.  
• Fracture involving the superior cortex of the anterior arch of C1 at the posterior aspect of foreign body.  
• Soft tissue defect seen after removal of foreign body.                                                                 | Mexico                          |
| 2016 | Kumetz EA, et al. [8]   | Case series      | Lithium-ion batteries                                                                                                                                                                                  | Extensive injury to his soft palate and front teeth.  
• Numerous superficial burns scattered about the patient’s perioral region, maxillary and mandibular lip laceration, tooth avulsion of the maxillary incisors and a hemostatic mass of hard and soft palatal tissue.  
• Commminuted left medial maxillary fracture with dislodgement of the bilateral maxillary incisors and tooth fragments impacted within the posteriorly displaced soft tissue mass.  
• Incisor (tooth no 7) was notable for enamel/dentin fracture  
• Incisor (tooth no 8 and 9) notable for root fractures and displaced crowns  
• Incisors (tooth no 10) complete avulsion.                                                                 | United States of America       |
### Table 1. Continued

| Year | Author | Type of Study | Initiation | Oro-facial injuries | Country               |
|------|--------|---------------|------------|---------------------|-----------------------|
| 2016 | Brooks, Justin, Brooks, & Reynolds [9] | Case report | After replenished e-cigarette with the e-liquid | • Missing of teeth 12, 11 and 21  
• Multiple teeth had varying degree of coronal damage  
• Teeth 14, 13, and 42 had severe vertical crown  
• Tooth 13 displayed grade 1 mobility and was tender to percussion.  
• Upper right lip moderately swollen and had several superficial lacerations.  
• Laceration on interior ventral tongue and upper right labial mucosa.  
• Superficial abrasion on left side of facial skin  
• Comminuted fracture of the anterior nasal spine that extended inferiorly to apical region of central incisors, fracture of the premaxilla with minimal displacement.  
• Tooth 21 had extruded through the labial alveolus and accounted for the presence of the soft tissue labial bulge. | United States of America |
| 2016 | Harrison & Hicklin Jr [10] | Case Report | After charging lithium-ion battery | • Tooth no 7 - subluxated  
• Tooth no 8 - root fracture  
• Tooth no 9 - lateral and extrusive luxation  
• Tooth no 10 - avulsed  
• Multiple fracture of the maxillary anterior alveolus  
• Burns on the dorsal surface of the tongue; coagulation necrosis of the superficial tissue  
• Burns of the maxillary anterior gingiva and mucosa; diffuse sloughing with frank ulceration | United States of America |
| 2016 | Brownson et al. [11] | Case Report (15 patients) | Internal battery overheating | • Blast injuries (27%) – led to tooth loss, traumatic tattooing, extensive loss of soft tissue, requiring operative debridement and closure of tissue defects.  
• Injuries to face (20%) | United States of America |
3.2 Discussion
Roger et al. was the first author to report the oro-facial trauma secondary to e-cigarette device. They described an 18-years old male suffered oral and abdominal burns and oral lacerations secondary to e-cigarette device explosion [2]. The reported patient, who also has attention deficit disorder, was described to have experienced device explosion while waiting for his presentation. The authors also raised concern of choking hazards and aspiration of foreign bodies.

In another report, Cason, Morgan & Pietryga discussed the explosion of e-cigarette that was initiated by lithium-ion batteries [5]. A 23-year old man experienced episode of injuries and burns on face, left hand, and chest. Computer tomography (CT) scan revealed that there were comminute fractures of his hard palate, and nasal septum and dislocation of the adjacent teeth. The patient was intubated before being referred to authors due to risk of inhalation injuries.

More recent case report proposed that improperly insulated lithium-ion battery and exposure to volatile liquids can lead to explosion of e-cigarette [6]. Authors reported that the 59-year old man encountered episode of explosion of e-cigarette while vaping that lead to multiple oro-facial injuries. Computed tomography revealed that there were fractures of the petrous, ethmoid, cribiform plate, nasal choanae, nasal septum, and right medial orbital wall as well as pneumocephalus. Authors noted that patient had bought the device online and claimed that there were no modifications of the device.

Another study reported explosion of e-cigarette in mouth after replacement with new lithium-ion battery that brought a complaint of moderate neck and throat pain, difficulty in swallowing and description a foreign body sensation [7]. CT scan revealed fracture involving the superior cortex of the anterior arch of C1 at the posterior aspect of foreign body and X ray conducted shows foreign body in the neck at the level of C1. This report demonstrated that e-cigarette device, with unique missile-like shape, can cause a serious penetrating injury, especially to oro-facial region when used.

Other studies have considered lithium-ion batteries as a possible cause of e-cigarette explosion that cause extensive injury to soft palate and front teeth [8]. In this case, numerous superficial burns scattered on the patient’s perioral region, maxillary and mandibular lip laceration, tooth avulsion of the maxillary incisors and a hemostatic mass of hard and soft palatal tissue. Moreover, CT scan revealed comminuted left medial maxillary fracture with dislodgement of the bilateral maxillary incisors and tooth fragments impacted within the posteriorly displaced soft tissue mass. This case series reported the spectrum of thermal and blast injuries secondary to malfunction of e-cigarette devices.

In an investigation of e-cigarette safety, Brooks et al. reported an e-cigarette explosion after replenished e-cigarette with the e-liquid in an 18-year old male patient [9]. Authors reported that during the event, the device propelled into the patient’s mouth and the opposite end of the device projected outwardly towards the wall leaving burn residue. Authors suggested a thorough neurology and oro-facial examination should be performed in patient experienced e-cigarette explosion and the airway competency should be assessed.

In the same vein, Harrison & Hicklin Jr in their case report noted multiple fractures of the maxillary anterior teeth and oral soft tissue injuries secondary to e-cigarette device explosion. The explosion happened after a complete cycle of charging of lithium-ion battery. The unlucky 28-year old man claimed to have used the e-cigarette device as an aid to smoking cessation and have been using it for 11 days [10].

The concern of internal battery overheating was also raised by Brownson et al. They reported a total of 15 patients were treated secondary to explosion of e-cigarette from October 2015 through June 2016. In the letter to editor, authors reported that the explosion had led to flame burns (80%), chemical burns (33%), blast injuries (27%), injuries to face (20%), hands (33%) and thigh or groins (53%) [11]. The letter raised concern on public safety and design changes of the devices as the e-cigarette device remains unregulated.

4. Conclusion
The evidence presented in our review concluded that the use of e-cigarette devices not only posed a safety concern but also the devices were mostly unregulated. Episodes of failure of battery operation,
small explosions, and fire hazard have raised concern of its operational standard. There should be a recognized authorized body to regulate the safety and standard operating of the electronic devices.

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