Clinical Report

Investigation of the Electric Handpiece-related Pneumomediastinum and Cervicofacial Subcutaneous Emphysema in Third Molar Surgery

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Abstract: Pneumomediastinum and/or cervicofacial subcutaneous emphysema are extremely rare but severe complications in third molar surgery. The most common cause is compressed air exhaust from an air-driven high-speed handpiece. To prevent these complications, treatment with an electric handpiece that does not use the drive air is generally recommended; however, its safety has not been fully verified. In this study, we investigated electric handpiece-related emphysema during third molar surgery. We evaluated patients who visited our hospital in relation to third molar surgery between January 2008 and December 2017. Of the 2938 patients examined, 2 patients were complicated with electric handpiece-related pneumomediastinum and cervicofacial subcutaneous emphysema during sectioning the mandibular third molar. In these cases, a straight motor handpiece and a 1:5 speed increasing contra-angle motor handpiece were used, respectively. Both patients received antibiotics and follow-up examination under hospitalization. Although the air flow and pressure of an electric handpiece are lower than those for air-driven high-speed handpieces, the air expelled from electric handpieces could cause cervicofacial emphysema and/or pneumomediastinum. It should be noted that electric handpieces do not use the drive air; however, most of these handpieces have air/water nozzles and use tip air. Before treatment, an informed consent to patients about the risk of emphysema is mandatory. With regard to the surgical technique, elevation of the mucoperiosteal flap should be minimal. Attention should be also paid to the possibility that the air inflow route is made through removal or perforation of the cortical bone. To prevent emphysema, an electric surgical handpiece with an external water spray may be preferable for removing the bone and cutting the tooth, because this type of surgical handpiece has a separate water drip for cooling instead of combined water and air spray, and it does not use the flux of air.

Key words: Electric handpiece, High-speed handpiece, Pneumomediastinum, Subcutaneous emphysema, Third molar extraction

Introduction

Subcutaneous emphysema is the invasion of air into the subcutaneous tissues. In the head and neck regions, the main causes of cervicofacial emphysema are maxillofacial trauma, infections, general anesthesia, head and neck surgery, coughing, and the Valsalva maneuver. Although emphysema is self-limiting in most cases, life-threatening complications such as pneumothorax, pneumopericardium, air embolism, and mediastinitis can occur. In dental and oral surgical procedures, tooth extraction, particularly mandibular third molar extraction, is the most common cause of subcutaneous emphysema and pneumomediastinum. Other causes are tooth restoration, root canal treatment, periodontal treatment, laser treatment, and tooth preparation for crown. Most of these procedures involve the use of an air-driven high-speed handpiece and compressed air syringe, which expel pressurized air into the surgical site. The expelled air could be driven into the submucosal tissue and fascial space. To prevent this complication, treatment with an electric handpiece that does not use the drive air is generally recommended, but the safety has not been fully verified. In this study, we investigate the pneumomediastinum and/or subcutaneous emphysema in relation to third molar extraction over a period of 10 years and identify the first two cases of pneumomediastinum and subcutaneous emphysema caused by an electric handpiece during third molar extraction. We discuss the symptoms, diagnosis, treatments, and the underlying mechanisms of these complications, and also propose methods to avoid emphysematous complications during third molar extraction.

Materials and Methods

We conducted a retrospective study on pneumomediastinum and cervicofacial subcutaneous emphysema during third molar extraction. Patients who were referred to the Department of Dentistry and Oral Surgery at the University of Fukui Hospital for third molar extraction between January 2008 and December 2017 were included. Diagnosis of pneumomediastinum and subcutaneous emphysema was confirmed using chest radiograph and computed tomography (CT) scan, which showed the presence of air in the cervicofacial subcutaneous tissues.
and/or mediastinum. The tooth indicated for extraction, the type of handpiece, and the clinical course were evaluated. This study complied with the standards of the Declaration of Helsinki and the current ethical guidelines, and was approved by the institutional ethics board (No. 20180064).

### Results
A total of 2938 patients [1333 men and 1605 women; mean age: 35 years, standard deviation (SD): 16 years] visited our department for third molar extraction. Among them, emphysema occurred in three patients during extraction of the mandibular third molar under local anesthesia. One patient developed subcutaneous emphysema caused by an air-driven high-speed handpiece (Fig. 1), and two patients presented

<table>
<thead>
<tr>
<th>Case no.</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Sex/age (y)</td>
<td>F/24</td>
<td>F/26</td>
</tr>
<tr>
<td>Extracted tooth</td>
<td>38</td>
<td>48</td>
</tr>
<tr>
<td>Handpiece</td>
<td>Contra-angle motor (1:5 speed increasing)</td>
<td>Straight motor</td>
</tr>
<tr>
<td>Onset</td>
<td>During tooth sectioning</td>
<td>During tooth sectioning</td>
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<td>Subjective symptom</td>
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<tr>
<td>Cervical swelling</td>
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<td>+</td>
</tr>
<tr>
<td>Others</td>
<td>Dyspnea</td>
<td>Dysphagia</td>
</tr>
<tr>
<td>Distribution of air</td>
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<tr>
<td>Facial subcutaneous</td>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>Buccal</td>
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<td>+</td>
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<tr>
<td>Cervicofacial subcutaneous</td>
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<tr>
<td>Suprahoidy</td>
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<tr>
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<td>+</td>
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<tr>
<td>Mediatinum</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Suspected route of air invasion</td>
<td>Removed buccal cortical bone</td>
<td>Perforated lingual cortical bone plate</td>
</tr>
<tr>
<td>Hospitalization (days)</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>CEZ, CTRX</td>
<td>CTRX</td>
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</table>

Abbreviations: CEZ, cefazolin sodium; CTRX, ceftriaxone sodium hydrate
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with pneumomediastinum and subcutaneous emphysema caused by electric handpieces. Characteristics of electric handpiece-related subcutaneous emphysema and pneumomediastinum in third molar surgery were illustrated in Table 1. The latter two patients were both young women, 24 and 26 years of age, respectively. The electric handpieces used were a 1:5 speed increasing contra-angle motor handpiece in case 1 (Fig. 2) and a straight motor handpiece in case 2 (Fig. 3). In both cases, electric handpieces were used for the purpose of removing the overlying bone and sectioning the tooth. The common subjective symptoms were cervical swelling. From the CT findings after the extraction, the suspected route of air invasion to the surrounding soft tissue was the space of removed buccal cortical bone in case 1 and the perforated lingual cortical bone plate in case 2. The clinical courses of both patients were uneventful, and without severe complications. On the other hand, no patients developed subcutaneous emphysema or pneumomediastinum caused by an electric surgical handpiece with an external water spray (Fig. 4).

Case Presentation

Case 1: A 24-year-old woman was referred to our department for extraction of bilateral impacted mandibular third molars (Fig. 5). The patient’s medical history included atopic dermatitis and an allergic reaction to clindamycin ointment. The right mandibular impacted third molar was extracted under local anesthesia without complications. During this procedure, a 1:5 speed increasing contra-angle motor handpiece (Fig. 2) was used to remove the overlying bone and section the tooth. Approximately 1 month later, the patient presented for extraction of the left mandibular impacted third molar under local anesthesia. After raising a
mucoperiosteal flap, which did not extend to the lingual cortical bone and the lateral oblique line, the same handpiece was used to remove the overlying bone and section the tooth. When tooth sectioning was finished, the patient complained of dyspnea. The procedure was discontinued. Physical examination showed swelling of the left orbital, facial, cervical, and supraclavicular regions, with crepitus on palpation and no erythema. The patient’s pulse rate was 117/min and blood pressure was 161/101 mm Hg, with an oxygen saturation of 99%. The initial diagnosis was subcutaneous emphysema caused by the use of the electric handpiece. A prophylactic antibiotic (cefazolin sodium 1 g) and glucocorticoid (betamethasone 4 mg) were administered. Then, the remaining tooth was completely extracted. The patient was admitted to our hospital for respiratory monitoring and antibiotic therapy (ceftriaxone sodium 1 g every 12 h). On the following day, swelling of the left orbital region was reduced, although diffuse swelling of the cervical region bilaterally, with crepitus and trismus, was observed. A laboratory test showed elevated white blood cell count (13.8 × 10^3/µl). A chest radiograph showed subcutaneous emphysema and pneumomediastinum (Fig. 6). A CT scan showed the presence of air in the cervicofacial spaces and mediastinum (Figs. 7, 8). According to CT, the suspected route of air invasion to the surrounding soft tissue was the space of removed buccal cortical bone (Fig. 9). On day 5, the emphysema was slightly reduced. On day 9, the patient’s symptoms were fully resolved, and subcutaneous crepitus was undetectable; a chest radiograph showed significant resorption of emphysema in all areas. The patient was discharged on the same day.

Case 2: A 26-year-old woman visited a dental office for extraction of the right mandibular third molar under local anesthesia (Fig. 10). To remove the bone and section the tooth, the dentist used a straight motor handpiece (Fig. 3). When the dentist tried to extract the roots of the tooth after removing the crown of the tooth, root tip fracture occurred. The dentist attempted to remove the interradicular septa, and extracted the retained root. Just after the procedure, acute right buccal and cervi-
handpieces are driven by compressed air at 0.20 to 0.29 MPa, with an 99% to 100% air flow. According to an instruction manual for air-driven high-speed handpieces, these handpieces have multiple air/water nozzles so that the aerosol produced during the procedure does not create an obstruction in the surgical site, which increases the risk of overheating at the bur/tooth interface. Air-driven high-speed handpieces expel drive air (the air used to power air-driven dental instruments), water, and tip air (the air supplied to the cutting surface to cool the tooth and flush debris). It should be noted that electric handpieces such as the straight motor handpiece and contra-angle motor handpiece (rotating at ~40,000 rpm) do not use the drive air, although most of these handpieces have air/water nozzles and use tip air at 0.2 MPa, with 1.5 l/min air flow (according to an instruction manual for electric handpieces). Although the air flow and pressure are lower than those for air-driven high-speed handpieces, the air expelled from electric handpieces may have caused cervicofacial emphysema and pneumomediastinum in the two cases presented in this study. One previous report describes a case of pneumomediastinum and pneumothorax after apicectomy using an electric handpiece under general anesthesia. The authors concluded that barotrauma after vomiting was the cause of emphysema and pneumothorax.

During third molar extraction, compressed air penetrates the soft tissue through the reflected mucoperiosteal flap and enters the fascial spaces, mainly the submandibular and masticator spaces. The neck is further divided into the suprathyroid and infrathyroid regions. The suprathyroid region includes the submandibular, sublingual, parotid, parapharyngeal, and masticator spaces. The infrathyroid region includes the visceral, anterior cervical, and posterior cervical spaces. Both the suprathyroid and infrathyroid regions comprise the carotid, retropharyngeal, perivertebral, and danger spaces. The neck consists of two layers of fascia, the superficial and deep layers. The superficial cervical fascia contains the facial muscles, the platysma, cutaneous blood vessels, nerves, and lymphatics. The deep cervical fascia consists of three or four layers. These fascial layers serve as anatomical barriers against the spread of infection; however, this anatomical arrangement could allow infection to diffuse easily throughout the fascial spaces.

With regard to emphysema, air in the cervical fascial spaces could reach the mediastinum easily via the parapharyngeal and retropharyngeal spaces. The common clinical presentation of emphysema is soft swelling of the cervicofacial region without redness and with crepitus on palpation. The signs and symptoms may develop immediately or within a few hours in most cases, whereas they develop several days after dental and oral procedures. Dyspnea with a “brassy” voice, chest or back pain, and the Hamman sign, which is a crunching sound during systole in the chest wall or neck on auscultation, may suggest pneumomediastinum. CT is recommended for detailed evaluation of air distribution, which cannot be performed using a chest radiograph. In the cases presented, CT and chest radiograph were useful for the initial diagnosis and follow-up, respectively.

Differential diagnosis is important to distinguish emphysematous complications from allergic reactions, hematoma, cellulitis, and angioedema. When the initial differential diagnosis is difficult, management using treatment prescribed for an allergic reaction may be the best option. In most cases, subcutaneous emphysema and/or pneumomediastinum are benign and self-limiting. These cases need observation with prophylactic antibiotics to prevent secondary infections caused by the introduced bacteria. Administration of 100% oxygen is recommend-
ed because oxygen can facilitate resorption of nitrogen in emphysema10. In severe cases, there have been reports of complications such as pneumothorax, mediastinitis, air embolism, cardiac failure, and cardiac tamponade1, 3.

With regard to the surgical technique, elevation of the mucoperiosteal flap should be minimal and should not extend to the lingual cortical bone plate11. When sectioning the tooth with air-driven high-speed and electric handpieces, close contact between the handpiece and the tooth should be avoided even without the elevation of mucoperiosteal flap, and the handpiece should not be used longer than required11, 32. For minimally invasive treatment, CT, especially with multiplanar reconstruction, is useful11, 34. In case 1, emphysema had not occurred during extraction of the right mandibular third molar, whereas pneumomediastinum and cervicofacial emphysema occurred during extraction of the left mandibular third molar. In case 1, one of the causes of emphysema might be maneuvers such as removing the overlying buccal cortical bone and sectioning the deeply impacted third molar using the handpiece with water and air spray. Compressed air from the nozzle of the handpiece might have penetrated the surrounding soft tissue and resulted in emphysema. In case 2, sprayed air from the nozzle of the straight handpiece might have penetrated through the perforated lingual cortical bone plate and spread extensively into the surrounding soft tissue. To prevent emphysematous complications during third molar extraction, an electrical surgical handpiece with external cooling spray is recommended. This type of surgical handpiece has a separate water drip for cooling instead of a combined water and air spray; in other words, it does not use the flux of air. Therefore, its use may lower the risk of emphysema10.

In conclusion, we have reported two cases of pneumomediastinum and subcutaneous emphysema caused by third molar extraction using an electric handpiece. To prevent emphysema during tooth extraction, an electric surgical handpiece with an external water spray is preferable for removing the bone and cutting the tooth.

Conflict of Interest

The authors declare no conflict of interest.

References
