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‘Causes of Subcutaneous Emphysema Following Dental Procedures: A Systematic Review of Cases 1993-2020'

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Abstract

Objectives

Causes of subcutaneous emphysema (SE) following dental treatment have changed with new operative techniques and equipment. This review demonstrates the frequency and aetiology of SE to inform prevention strategies for reducing SE occurrences.

Methods

A systematic search of Medline, Embase and PubMed databases identified 135 cases of SE which met inclusion criteria after independent review by two authors. Trends in frequency and causes of SE were displayed graphically and significant differences in frequency of SE by time period, site and hospital stay were analysed using t-tests.

Results

Dental extractions often preceded development of SE (54% of cases), commonly surgical extractions. Treatment of posterior mandibular teeth most often resulted in development of SE. Most cases were iatrogenic with 51% resulting from an air-driven handpiece, and 9% from air-syringes. Factors such as nose blowing accounted for 10%.

There was a significant ($p < 0.05$) increase in cases over time. Mandibular teeth had increased hospital stay time compared to maxillary teeth ($p<0.01$).

Conclusion

Increased risks of SE were identified following use of air-driven handpieces during dental extractions and when treating lower molar teeth. Use of air-driven handpieces should be avoided during dental extractions to reduce risks and subsequent morbidity that results from SE.

Introduction

Subcutaneous emphysema (SE) is a rare but well-documented complication of dental procedures, most commonly associated with dental extraction. In the one-hundred years since the first documented case[1] the aetiology of SE has shifted towards predominantly iatrogenic causation. The use of high-speed air rotors in dental procedures which disrupt the mucogingival barrier is widely accepted as a risk factor for development of SE. A systematic review of cases in the early 1990's[2] identified use of high-speed air rotors during surgical removal of teeth as the most common factor in developing SE after dental procedures. The American Association of Oral and Maxillofacial Surgeons[3] has advised against their use in this way since that time. Two systematic literature reviews (Heyman 1995[2] and McKenzie 2008[4]) have approached this topic previously. Heyman provided a comprehensive account of cases 1960 – 1993. McKenzie reported 1993 – 2008 but was of limited scope.

Advancing technology has provided access to surgical handpieces which no longer rely on compressed air or use a 'reverse exhaust' system. However, frequent cases of SE continue to be reported in the literature[4]. These cases likely reflect a fraction of the true prevalence as mild cases may go undiagnosed or unreported. The impact of recent technological developments, such as air-powered prophylaxis or air-cooled dental lasers- which are designed to be used at the gingival margin or subgingivally, is not known.

Cases of SE are rare, but the health risks to patients can be severe, hence the need for attention to preventive measures, diagnosis, and onward referral for treatment if necessary. Some cases progress to life threatening complications requiring admission to critical care. [5] The aims of the investigation were therefore to identify the prevalence, burden and risk factors associated with SE so as to inform preventive strategies to avoid SE in dental settings.

Specific objectives were to:

1. Identify frequency of SE in a dental setting and explore trends over a 28-year period.
2. Identify causes of SE in a dental setting and explore differences in frequency of SE over 2 time periods and by site and hospital stay.
3. Inform prevention strategies to reduce SE occurrences in a dental setting.

Materials & Methods

The study design was a systematic review of published SE cases. Three electronic databases were searched to identify published English language cases of SE reported between 01/01/1993 and 01/01/2020 (See Figure 1). All cases of SE following an intra-oral intervention were included which contained minimum outcomes: patient age and sex, dental procedure performed, suspected contributing cause, anatomical distribution of subcutaneous air, treatment provided for SE, length of hospital stay, and time to full recovery. Cases of SE following facial trauma or orthognathic surgery were excluded (See Figure 2).

Duplicates were removed along with irrelevant papers based on title and abstract by two authors (AJ and RM). The remaining papers were reviewed in full against our inclusion criteria for reported outcomes. Forward and backward citation searching was performed, identifying an additional four relevant papers. A search of grey literature failed to reveal any further relevant papers. Papers which reported several cases were recorded as individuals case level if outcomes were attributable, they were excluded if not. See Figure 1 for details of handling of search results and reasons for exclusions. Trends in frequency and causes of SE were displayed graphically and significant differences in frequency of SE by time period, site and hospital stay were analysed using t-tests.

Results

180 reports of iatrogenic SE of dental origin were identified. 135 cases had sufficient detail for inclusion (See Table 1.)

Mean reported cases increased from 2.6 per year between 1993 and 2006 to 7.1 per year 2007-2020 (p= <0.01).

Patient demographics

The mean age of affected patients was 37.9 years (SD= 18.1) with a range of 4-80 years. Females (n=84) were more often affected than males (n=44). Sex was not reported in eight papers.

Causes

- *Air-driven handpieces:*

  The majority cases resulted from the use of an air-driven dental handpiece following disruption of the oral mucosa (51.1%). Most of these cases occurred following surgical removal of a tooth (62%). Some resulted from a restorative procedure such as a restoration or crown preparation (28%). The remainder occurred after non-surgical endodontic procedures (10%).

- *Patient factors:*

  10.4% of cases resulted from a post-operative patient action. Some examples included nose blowing, sneezing, inflation of a balloon, use of a peak flow meter or vigorous exercise. 80% of these cases followed dental extractions (either surgical or routine). The remaining cases followed invasive procedures such as sinus augmentation or zygomatic implant surgery.

- *Air-syringe:*

  Use of an air-syringe near a mucosal breach was implicated in 9.6% of cases. 33.3% of these followed non-surgical endodontics, 33.3% followed dental restorations, and 16.7% followed non-surgical dental extractions. The remaining cases resulted from a crown preparation and surgical extraction respectively.

- *Air-prophy systems*

  Air polishing/prophylaxis systems accounted for 3.7% of cases, half of these resulted from use around dental implants, the remainder from routine periodontal treatment.

- *Dental lasers*

  3% of cases resulted from dental laser use, these were all related to oral surgery procedures.

- *General anaesthetic factors:*

A small number of cases followed treatment under general anaesthetic (3%). These cases were more extensive but often related to an intubation complication rather than treatment factor.

- *Unknown cause/Not reported*

19.3% of cases were of unknown or unreported cause. These were distributed by procedure between routine dental extraction (28%), non-surgical endodontics (28%) and surgical dental extraction (24%). The remaining cases resulted from non-surgical periodontal treatment (8%), crown preparations (4%), laser use (4%) or restorations (4%).

Procedure, tooth and location

Figures three, four and five demonstrate the breakdown of cases by procedure preceding development of SE, tooth and position.

Spread of subcutaneous air

There were seven reported cases of pneumothorax which did not result from general anaesthetic (GA) complications. Six of these cases involved surgical removal of a lower molar tooth and five involved use of an air-driven handpiece. The remaining case resulted from an air-driven handpiece used for non-surgical endodontic treatment. See Figure 6 for tissue space spread of subcutaneous air.

Diagnosis and treatment

Antibiotics were prescribed in 76% of cases. Typically, these were broad spectrum, most commonly Co-Amoxiclav. Figure 7 shows the breakdown of diagnostic imaging performed by modality.

Hospital admission:

Eighty-five patients (63%) were admitted to hospital. The mean length of stay was 4 days (SD: 4.7), maximum stay was 31 days. The mean time to complete resolution of symptoms was 7.3 days (SD: 4.8). SE following treatment of a mandibular tooth was associated with a mean hospital stay of 3.45 days compared with 2.5 days for maxillary teeth ($p=0.01$). As expected, the extent of spread of SC air was related to length of hospital stay, mean hospital stay for pneumothorax was 10.6 days, whereas SC air spreading to the peri-orbital region resulted in a mean stay of 0.5 days.

Discussion

The current review showed a significant increase of frequency of SEs in the dental setting. Of importance were the findings that these cases could be readily prevented as the majority were caused by use of an air-driven handpiece in the removal of a tooth. Furthermore, the risk of SE was higher in posterior mandibular teeth and such cases also presented with higher morbidity in the form of increased hospital stay which in turn increases the burden on already stretched healthcare resources .

The most common causative factor across the reported cases was use of an air-driven dental handpiece to assist in removal of a tooth. These findings mirror previous reviews of the literature.[2, 4, 132] SE is rare but was most likely to develop following procedures involving posterior mandibular teeth, this may be due to the anatomical structure of the region allowing easier air dissection of the tissues. We theorise this increased disposition of lower molar teeth to SE complication may be related to extraction complexity, i.e., the increased likelihood of lower molar teeth requiring surgical removal due to impaction, root morphology or relative thickness of cortical bone in the posterior mandible. SE caused by use of air-driven dental drills during extraction of teeth is avoidable and use of safe alternatives such as motorised surgical handpieces should be encouraged. Further research is required to understand the reasons practitioners may choose an air-driven handpiece, and how transition to safer alternatives can be supported.

We identified an increasing trend in reported cases, similar to previous reviews,[2, 132]. Although this may well reflect an increasing volume of published scientific literature, if this is not the case then it is of concern that the incidence of this largely preventable complication continues to increase. Also notable is the continued trend away from patient-related causes of SE (typically resulting from a transient increase in intra-oral pressure), towards iatrogenic causation. This increase began in the mid 20th century and likely reflects the introduction of the air-driven turbine to dentistry. In 1993, Heyman [2] et al in found 72% of cases were attributed to use of high-speed air powered turbines. This proportion has increased (78% for cases following oral surgery) from 1993 – 2020 even without consideration of new technology which utilises compressed air, such as intraoral laser and air-prophy systems. Given that the American Dental Association has advised avoiding use of pressurised air handpieces for surgical procedures since 1993, [3] we might have expected this proportion to decrease, particularly as surgical drills with reverse exhausts or not employing compressed air are now widely available.

A proportion of cases still result from patient related factors, such as vigorous mouth rinsing, nose blowing, or sneezing with a closed mouth. These are may be avoidable with clear and concise post-operative instructions following dental treatment.

When considering options for treatment, it is difficult to make assumptions from limited published case information on cases which span continents, cultures and medical systems. The reported role of antibiotics in management of SE is to prevent local or systemic infection by oral flora.[107] Regardless of whether antibiotics were administered it is interesting to note that only one incidence of infection was reported in the cases examined here [133]. This finding reflects Heyman et al[2], and further research is necessary to understand when antibiotics might be necessary in cases of SE.

Fortunately, no deaths resulting from SE were reported. This is in keeping with previous reviews which suggested SE is typically non-fatal and self-limiting.[2,4,134] During a dental procedure the volumes of gas passed into the tissues are likely to be low and so less likely to contribute to respiratory or cardiovascular compromise.[133] Nonetheless, the psychological impact on the patient and the cost implications [134, 135] for healthcare services should not be underestimated (the mean hospital stay was 4 days and investigations were often numerous). This is particularly important when considering the largely avoidable nature of SE.

Reporting of cases of SE came from a wide variety of medical journals. Medical practitioners tended to report milder instances presented as illustrative examples to raise awareness of the condition among colleagues.[1, 6-12, 15, 16, 20, 21, 24, 26, 27, 29-31, 33, 36-38, 43, 46, 47, 52-54, 57-62, 66-71, 74-76, 78, 81-86, 89-91, 93-95, 98, 99, 101, 102, 106, 108, 111, 113, 115-117, 119-121, 125-131] When cases were reported in dental journals they were often more severe, or had unusual or unexpected aetiology.[10, 13, 14, 17-19, 22, 23, 25, 28, 32, 34, 35, 39, 42, 44, 45, 48, 49, 51, 55, 56, 63-65, 72, 73, 77, 79, 87, 88, 92, 96, 97, 100, 103-105, 107, 109, 110, 112, 114, 115, 118, 122-124] This likely reflects a wider recognition of the likelihood of SE among dental professionals. Non-reporting of adverse incidents is well recognised in the medical and dental literature and there are ongoing efforts to promote reflective analysis of such events.[136-138]

Although rare, the sudden onset of a rapid swelling in the head and neck can be an alarming experience for a patient and the attending clinician alike, especially if linked to a respiratory restriction and the need for emergency medical care. Appreciation of the cardinal signs of SE enables differentiation from conditions with similar presentation such as anaphylaxis or angioedema. SE often presents as rapid onset soft tissue swelling and crepitus on palpation

of the swelling is pathognomonic.[139] Dysphonia, dysphagia and dyspnoea may be present. Discomfort is commonplace, as are symptoms associated with the anatomical spread of subcutaneous gas, for example trismus when the sub-masseteric space is involved.[139] Patients should be monitored for signs of respiratory and cardiac distress. “Hamman’s sign” - a crunching sound synchronous with heartbeat on cardiac auscultation [140] - may be heard when pneumomediastinum has occurred. ECG changes such as ST segment elevation or T wave inversion may indicate pneumopericardium.[141] Radiographic investigations can determine the extent of gas dissection, with CT outstripping conventional plain film as the imaging modality of choice for most cases reported in this series.

Crucially, all clinicians must consider all aspects of their protocols and standard operating procedures to ensure they provide high quality care for their patients.[142] Risk mitigation is a cornerstone of this process, where choice of surgical equipment is potentially one of many complicating factors.[143] In recent years there have been attempts to improve patient safety in primary care dentistry and in most cases, this revolves around safety checklists.[144] Subsequently in the UK, the evolution of safety checklists has formed one arm of wider attempts to improve patient safety through National and Local Protocols around invasive procedures.[145] By engaging with the wider team and considering all facets that may impact patient safety and quality of treatment, adverse outcomes such as SE might be avoidable.[146]

Conclusions:

- Subcutaneous emphysema is a rare complication of dental treatment. It is more likely to be precipitated by certain dental surgical techniques, particularly the use of air-driven handpieces for extraction of teeth. It is also more common following treatment of teeth in the posterior mandible.
- Although SE is generally self-limiting, and few cases result in long-term health consequences, there are pain, anxiety, inconvenience and cost implications for patients.
- All clinicians should be aware of the possibility of SE resulting from a dental procedure, have knowledge of diagnosis and early management, including when to consider referral to secondary care.

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Goorhuis H et al [7]	1993

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Bokkenkamp DM [10]	1996
Karras SC et al [11]	1996
Torres-Melero J et al [12]	1996
Staines K et al [13]	1998
Capes JO et al [14]	1999
Salib RJ et al [15]	1999
Chen SC et al [16]	1999
Ali A et al [17]	2000
Sekine J et al [18]	2000
Wakoh M et al [19]	2000
Bumpous JM [20]	2001
Davies DE [21]	2001
Hata T et al [22]	2001
Penna KJ et al [23]	2001
Sood T et al [24]	2001
Oliver R et al [25]	2002
Barkdull TJ [26]	2003
Aquilina P et al [27]	2004
Smatt Y et al [28]	2004
Fruhaf J et al [29]	2005
Iqbal M et al [30]	2005
Schneider LA et al [31]	2005
Chung IH et al [32]	2006
Desai, H [33]	2006
Karki AJ et al [34]	2006
Mather AJ et al [35]	2006
Satilmis A et al [36]	2006
Torgay A et al [37]	2006
Yang SC et al [38]	2006
Chan DCN et al [39]	2007
Vidal CAG et al [40]	2007
Kumar D et al [41]	2007
Steelman RJ et al [42]	2007
Sujeet K et al [43]	2007
Uehara M et al [44]	2007
Gulati A et al [45]	2008
Magni G et al [46]	2008
Porteri E et al [47]	2008
Arai I et al [48]	2009
Cicciu M et al [49]	2009
Ghali Eskander M [50]	2009
Imai T el al [51]	2009
Kung JC et al [52]	2009
Parkar, A [53]	2009
Samuels TL [54]	2009
Kim Y et al [55]	2010
Matsuzawa N et al [56]	2010
Pousios D et al [57]	2010
Sainsbury, D. et al [58]	2010
Afzali N et al [59]	2011
Coulier J et al [60]	2011

Hsu HL et al [61]	2011
Maxwell MG et al [62]	2011
Romeo, U. et al [63]	2011
Uyanik LO et al [64]	2011
Bilecenoglu B et al [65]	2012
Chen CH et al [66]	2012
Dongel I et al [67]	2012
Durukan P et al [68]	2012
Guillen-Paredes P et al [69]	2012
Suzuki J et al [70]	2012
Terzic A et al [71]	2012
Abrahams, J. M [72]	2012
Al-Qudah A et al [73]	2013
Bergen T [74]	2013
Elia F et al [75]	2013
Khandelwal V et al [76]	2013
Mitsunaga S et al [77]	2013
Olate S et al [78]	2013
An GK et al [79]	2014
Baisi A et al [80]	2014
Fleischman D et al [81]	2014
Haitz et al [82]	2014
Johannesma PC et al [83]	2014
Lim JL [84]	2014
Mishra L et al [85]	2014
Aslaner MA [86]	2015
Fulton G [87]	2015
Kim KH et al [88]	2015
Lococo F et al [89]	2015
Nishimura T et al [90]	2015
Onal O et al [91]	2016
Picard M et al [92]	2015
Sakakibara A et al [93]	2015
Shimi A et al [94]	2015
Tomasetti P et al [95]	2015
Wong C et al [96]	2015
Farina R et al [97]	2016
Manas Vera MR et al [98]	2016
Soylu E et al [99]	2016
Vargo RJ et al [100]	2016
Yepez-Ramos, D. et al [101]	2016
Akra GA et al [102]	2017
Alonso V et al [103]	2017
Boggess WJ et al [104]	2017
Gowans K et al [105]	2017
Ishikawa, K. et al [106]	2017
Lee SW et al [107]	2017
Ramnarine, M. et al [108]	2017
Sahoo NK et al [109]	2017
Tan S et al [110]	2017
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Chang CH et al [113]	2018

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Lee ST et al [115]	2018
Liu CC et al [116]	2018
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Zaheer S et al [119]	2018
Zaigham, S [120]	2018
Chang JR et al [121]	2019
Chien PH [122]	2019
Costa RR et al [123]	2019
Cuccia AM et al [124]	2019
Fehrle C et al [125]	2019
Mascarenhas, R. J [126]	2018
North L et al [127]	2019
Paschos KA et al [128]	2019
Rad, M. V et al [129]	2019
Pan Y [131]	2020
Kaliszewski, K. et al [130]	2020

Table 1. List of included case reports of SE.