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"The Flying Tooth" - A Detailed Review of Aviation Dentistry

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Abbreviations

1. & - and
2. e.g – Example
3. FAA - Federal Aviation Administration
4. Ft - Feet
5. G - Gravitational Forces
6. TMJs – Temporo-mandibular Joints
7. US- United States
8. Vs – Versus

Abstract

Aviation and aeronautic dentistry is a developing and an upcoming field of science, which studies the influence of flying and its effect on the oral cavity. It has gained popularity in recent years and is frequently observed in frequent flyers, crew members and in pilots. With the skyward trend in airline travel, flight-related oral conditions at a higher altitude will be requiring treatment and also have become a source of concern for aircrew members too. Due to the closed chamber, there is an accumulation of pressure which causes pain, discomfort and even organ dysfunction. Proper diagnosis can help in avoiding various complications and also show a better and well-understood treatment pathway. The unusual nature of aerospace medicine requires practitioners to have unique expertise and thus, dentists should be aware of these facts and provide a treatment inclusively.

The main aim of this article is to appreciate the flying effects on dental health and to prevent disorders combined with changes in atmospheric pressure.This article reviews why aviation dentistry or aerospace medicine is an important topic and why its understanding plays a key role for every dental surgeon.

Keywords- *Aviation dentistry, Aerospace medicine, Aeronautical dentistry.*

Introduction

Aerospace medicine or Aviation dentistry is the discipline that manages the determination and maintenance of the health, safety and performance of those who fly in the air or into space. Aviation dentistry deals with the oral and dental health status of the aviators while mainly overseeing the diagnosis, disorders of the oral and maxillofacial regions and their impact, on people who commute to such environments with abnormal changes in atmospheric pressure. Whenever a person travels towards a higher altitude (i.e 18,000 ft and above), there is a change in the atmospheric pressure and its related effects will be seen on the body too.

With high speed, altitude, low pressure, gravitational (G) forces and movements in the 3 axes during flight, potential major problems can be induced. Disorders caused by G-forces and fear of flying, can result in hypoxia, vertigo, air sickness, decompression illness (including barotitis, the expansion of gases in the abdomen), visual illusions and jet lag.

Introduction to (aero)space environment, through aicrafts have significant medical and health implications in air crew members. Adjustment of human physiology to such an environment of space is a difficulty faced, in the progress of human space flight travel. Due to the rise in airline travel and its

increasing popularity, flight-related oral conditions which require treatment have increased in the aircrew members. People (in-flight) are subjected to the reduced air pressure and are noticed with an expansion of the the gases, present within the body. In cases where the gas can communicate with the external environment, (e.g. nose, mouth) the pressure gets dissipated, but when there is no outlet for the gas to dissipate, the pressure builds up, leading to pain, discomfort and even impaired organ function.[1-8]

Dental barotraumas arenoted more among military personnel than in civilian air passengers.[9] Sometimes, barodontalgia can go unnoticed due to carelessness.10 There should be better knowledge on aviation dentistry among both dentists and air crew members to manage and treat in flght adverse events.

Etiology [11]

As it's seen, barodontalgia is a symptom rather than a pathologic condition itself and in most cases it reflects as a flare-up of pre-existing subclinical oral disease. Many common oral pathologies have been reported as the possible origin of barodontalgia.

A few noted etiologies reported as causes of barodontalgia during flights include- Barosinusitus (indirect barodontalgia),Recent dental treatment (postoperative barodontalgia), Faulty restoration/dental caries without apparent pulp involvement, Vital pulp pathology (exposure, pulpitis), Necrotic pulp/periapical pathology (including vertical root fracture) and impacted tooth.

Clinical reports of barodontalgia, noted due to external otitic barotrauma (caused by expansion of air in earphone) and to dental barotrauma (barometric pressure–related fracture of dental hard tissue and/or restoration) are noted too. Together with barosinusitis, these examples of facial and dental barotrauma, respectively, are unique as barometric-related pathologic conditions that are generated during the flight from pressure changes rather than a pressure-related flare-up of pre-existing conditions.Barodontalgia originated from referred pain of facial barotrauma is termed indirect barodontalgia.

	Direct barodontalgia owing to pulp disease with or without peri-apical involvement	**Indirect barodontalgia**
Cause	Pulp/peri-apical disease.	Barosinusitis, barotitis media
Appearance	Pulpitis: During take-off/ascent. The pain usually appears during landing at the appearance level. Peri-apical periodontitis: usually at high altitude (38,000 ft) during ascent or landing.	During landing and the pain usually continues on the ground.
Symptoms	Irreversible pulpitis: Sudden sharp penetrating pain. Reversible pulpitis or necrotic pulp: Beating dull pain. Peri-apical periodontitis: continuous strong pain, swelling.	Toothache in upper premolar/molar region
History	Recent dental treatment, Recent dental sensitivity (e.g to cold drinks, percussion/eating).	Present acute upper respiratory infection, Past sinusitis
Clinical findings	Extensive caries lesions or (faulty) restoration. Acute pain upon cold or percussion test.	Pain on sinus palpation. Pain upon a sharp change in the head position
Radiological findings	Pulpal caries lesions and/or restoration close to pulp-horn, Peri-apical radiolucency, Inadequate endodontic obturation.	Opacity (fluid) on the maxillary sinus image

Table 1- Direct vs Indirect Barodontalgia

Boyle's Law and Barotrauma [12**]**

According to Boyle's Law, the volume of gas at constant temperature varies inversely with the surrounding pressure. The volume of gas inside the body's rigid cavities tends to change, associated with the changing atmospheric pressure and may result in several adverse effects, known as barotraumas.

Normally, there is no air pressure differential between the sinuses and the outside environment. Barosinusitis is an acute or chronic inflammation of one or more of the para nasal sinuses, produced

by the development of a pressure difference (usually negative) between the air in the sinus cavity and that of the surrounding atmosphere. However, when the normal sinus outflow is compromised, as may occur during upper respiratory tract inflammation, a pressure gradient is created resulting in a vacuum effect that may be stressful to the sinus mucosal lining. The vacuum may cause mucosal edema, sero-sanguineous exudates and sub-mucosal hematoma, which may consequently cause pain, sometimes abrupt and severe and possibly epistaxis. Subsequently,pain and numbness may occur as a result of pressure on branches of the trigeminal nerve in the maxillary sinus. Barosinusitis's incidence during descent is about double that of during an ascent.

The dental relevance of non-dental head and face barotraumis as follows:

1. Barotitis-media or barosinusitis can follow and may be manifested as toothache.
2. A relationship exists between dental malocclusion and Eustachian tube dysfunction.

Dental Barotrauma

Barotrauma is tissue damage caused by a difference in pressure between a gas space inside the human body and the surrounding fluid during flight, diving, or hyperbaric oxygen therapy. Thus, barotrauma can easily damage several different areas of the human body. There have been reports in the past and along with predisposing factors pointing towards in-flight dental fractures and even reports in several cases have also shown the same within-vitro models. Fracture of the restorations have also been noted and though the exact reason here cannot be pin pointed always without seeing the condition of the initial restoration clinically, but an assumption can be, due to a microleak caused due to either improper adaptation and condensation of the dental material and even can be caused if the proper technique and material science is not understood fully and adapted well, clinically. Restorations (with Microleak) may cause dental fractures, also known as Odontecrexis, under variable atmospheric pressure. Therefore, faulty restorations should be (re)restored at the time of preflight dental examinations to prevent the worst.

Barotrauma & Barodontalgia

External otitic barotrauma, barotitis media, barosinusitis, barotrauma-related headaches, dental barotrauma, and barodontalgia are a few conditions that may be caused due to Barotrauma.**[**7,13**]**

The most common flight-related oral disorders are considered to be the result of barodontalgia, which is an acute symptom of subclinical oral or dental disease due to the changes in barometric pressure at high altitude.**[**14**]**

Barodontalgia (previously Aerodontalgia), is a dental pain, which is evoked by a change in barometric pressure, in an otherwise asymptomatic tooth and may be severe enough to cause in-flight vertigo,

incapacitation and premature cessation of flights and altitude-chamber simulations.**[**15-17**]** Barodontalgia has been reported to occur across a range of altitudes, but is more common between 9000ft and 27000ft3.These types of troublesome conditions can reduce the flight competency of aircrew members and flight restriction of a patient is required when interference with flight safety is suspected.**[**15**]** Few common oral pathologies which have been reported as a possible origin for barodontalgia include; dental caries, defective tooth restoration, pulpitis, pulp necrosis, apical periodontitis (jawbone cyst and granuloma), periodontal pockets, impacted teeth, and mucous retention cysts.**[**18,19**]**

One exception noted is barodontalgiacan be displayed as referred pain from barosinusitis or barotitismedia. The latter two conditions are generated from pressure changes rather than a pressure-related flare-up of pre-existing conditions. Several suggestions have been made to explain the mechanism underlying barodontalgia in pulpitis: **[**19-22**]**

1. Direct ischemia, resulting from inflammation itself.
2. Increased intra-pulpal pressure as a result of vasodilatation and fluid diffusion to the tissue can cause Indirect ischemia.
3. The result of intra-pulpal gas expansion.
4. The result of gas leakage through the vessels because of reduced gas solubility.

This theory was based on a histological view of gas bubbles on sectioned teeth that were extracted after barodontalgia. **[**22-25**]**

Classification [25-29**]**

The sub-grouping of Barodontalgia can be made into the following groups-

Direct (dental induced) and Indirect (nondental induced) pain. Currently, there are 4 classes of the accepted classification, which are according to pulp/periapical condition and symptoms (Table 2).

Class	Pathology	Features
I	Irreversible pulpitis	Sharp transient (momentary) pain on ascent
II	Reversible pulpitis	Dull throbbing pain on ascent
III	Necrotic pulp	Dull throbbing pain on descent
IV	Periapical pathology	Severe persistent pain (on ascent/ descent)

Table 2- Classification of Direct (Dental Induced) Barodontalgia

Maxillary and mandibular teeth are affected equally during flying conditions. The most affected intraoral areas as per studies are the posterior maxillary region and mandibular teeth with the maxillary first molar and mandibular first molar being the most affected teeth.

The pain was usually categorized in severe and moderate to severe range. Pain may discontinue on returning to approximate onset level 3,000- 10,000 ft or ground atmospheric level. In many cases when pain is caused by periapical disease or by facial barotrauma, it lasts upto 3-7 days after landing.

Oral and Maxillofacial Region Considerations

Medications

Airplane restriction of a patient is needed when the flight capabilities of an aircrew member are compromised and pose an in-flight hazard. Certain medications namely, opiates, can cause dullness or poor concentration, whereas some antibiotics can cause diarrhea. A medical condition requiring the use of antibiotics is the main reason for the grounding of aircrew members.**[**15**]**

According to FAA instructions, if the medication label warns of side effects, the grounding of aircrew is compulsory for at least 5 times the half-life of the medicine or, if the half-life is not indicated, until 5 times the maximum recommended dosing interval has passed.

Tooth Extraction

A few studies have found that intra-oral pressure changes occur during flight and negatively impact the healing process in the early post-extraction period. These pressure changes can dissolve the blood clot. Dissolution of the clot could result in excessive intraoral bleeding and interference with normal functions, particularly speech. Extraction of the posterior maxillary tooth/region, the site must be explored for oroantral communication and if it is noted a referral to an oral surgeon for its closure must be made. Oroantral communication can lead to sinusitis and hence barometric pressure changes may evoke barosinusitis and barotitis media or cause other adverse outcomes. **[**2,29**]** The risk of developing emphysema can also increase as a result of a pressure-changing environment. These unpleasant conditions can reduce the flight capabilities of aircrew members, and flight restriction of a patient is required when interference with flight safety is suspected. To prevent complications, the usual restriction time after dental extractions is 24-72 hours for symptomatic relief, cessation of medication, and stabilization of the blood clot (Table3).

In cases of oroantral communication, grounding should be advised until healing is evident, as changes in pressure can interfere with wound healing.

Treatment	Limitations
Tooth extraction or oral surgery	24-72 hours
Endodontic treatment	24 hours
Dental implant surgery	10 days
Placement of tissue membrane	7-14 days
Severe malocclusion or maxillofacial tissue disease	Dismissed and assigned to a ground position

Table 3 -Flight limitations for pilots according to US Federal Aviation Administration guidelines

Odontogenic Cysts or Tumors [2,29,30**]**

Various studies have shown the effect created by barotrauma on the oral and maxillofacial region. Macaluso & Galli reported a case scenario of inferior alveolar nerve paresthesia. They also noted that barometric pressure changes could also cause rapid cyst expansion with loss of sensation.It is also seen that the quicker the altitude increases, greater is the increase in barometric pressure, leading to rapid cyst expansion. A sudden decrease in atmospheric pressure may cause transient inferior alveolar nerve compression,eventually resulting in a long-term impact on the expansion of the cyst. External pressure changes tend to bring about temporary pressure on the sensory fibers of the alveolar nerve. These sudden pressure changes can also cause capillary collapse, that deprives oxygen to nerves and blocks conduction. Experimental studies have found that a longer nerve compression interval results in a longer latency period before recovery.

Bruxism [2,15,31,32**]**

Bruxism may bring about a variety of signs and symptoms, including pain and may cause irreversible damage to the teeth, periodontium, masticatory muscles and temporomandibular joints. Researchers have speculated that the higher prevalence of jaw parafunctional activity in aircrew members derives from inflight hazards such as G-forces, vibrations, or centrifugal forces.

Other work parameters, such as irregular shifts, have also been associated with bruxism. Studies have shown that bruxism is more prevalent among pilots than non-pilots.

Xerostomia [2,32-34**]**

Chronic stress and workload under harsh environmental conditions can affect the chemical composition of saliva and its flow rate. Levels of Immunoglobulin A in saliva, were shown to significantly decrease during flight, during studies. For maintaining proper mucosal immunity, proper hydration is critical. At

high altitudes with low air pressure, excess water loss occurs through the breathing of dry, compressed gases in the aircraft, leading to more pronounced hyposalivation and dryness of the mouth. Caries and periodontal diseases are potential long-term consequences of xerostomia. Increased fluid intake is recommended to increase salivation and prevent dryness of the mouth. In severe cases, artificial saliva substitutes can be prescribed.

Oral Bacteria [3**]**

It has been seen that humans suffer immune suppression with prolonged space flight. Bacteria show less susceptibility to antimicrobial agents in microgravity. An increase in the development of biofilm is noted and its resistance to antibiotics is seen as well, thereby enhancing their chances of survival in hostile environments and becoming more infectious and dangerous to human health.

Dental Implants [2,3**]**

The quality criteria that must be assessed after implants are placed in aviators include fixation, radiographic examinations, mucous membrane–gingival harmony, occlusion and articulation. The quality and quantity of the local bone influence the primary stability of an implant and are among the main factors influencing implant survival rates. In cases of maxillary sinus augmentation procedures, flight restrictions are required due to pressure changes in the flight.

A study was conducted to evaluate the peri-implant bone changes around a dental implant, in which dental implant was placed in a French astronaut who had spent 6 months in Russia's Mir space station. Intra-oral examination and required measurements were recorded by 2 examiners before the flight, after the flight, and following a recovery period.

Periapical radiograph was taken and was found that the peri-implant bone level remained the same after 6 months in microgravity and the implant continued to function without any complications.

Prosthesis and Dental Restorations [34**]**

Retentions of denture prosthesis are solely based on atmospheric pressure, adhesion, and gravity. This entails both maxillary and mandibular dentures, among which maxillary dentures totally depend on them. Reduced barometric pressure can impair the retentions of complete dentures. In prosthetic crowns, pressure changes occur in microtubules in the cement layer, which results in reduced retention of the crown. Mostly, the cement layers beneath the crowns become weak due to microleakage.

A clear distinction between "v" and "f " and between " s " and " sh " should be maintained in cases of extensive incisors rehabilitation and high regard and attention must be given to phonetics as it plays a

very crucial role for pilots and specially for military aircrew members and it's pilots.15 A study showed that the retention of cast crowns on extracted teeth, was reduced after pressure cycling, when they were cemented with either zinc phosphate cement or glass ionomer cement. In another study, Lyons et al found that crowns cemented with glass ionomer or zinc phosphate cement could easily be weakened under repetitive flight conditions, owing to the expansion of microporosities incorporated at the time of manipulation, no microleakage was detected in resin cement.

Dentists should consider using resin cement when they cement crowns and fixed partial dentures for patients, such as divers, who are likely to be exposed to pressure cycling. Use of a provisional restoration or temporary cementation is not recommended for aircrew members.**[**2**]**

In a study conducted by Calder & Ramsey, a comparison of the decompression strength of composite resin and amalgam restorations was done and it was reported that teeth with amalgam restorations had a higher prevalence of dental fractures than did teeth with composite resin restorations, because of undesired gaps between the tooth and restoration walls. It was also found that the unfavourable gaps and differential thermal contraction of amalgam restorations in cases of low temperature in a high-altitude environment can lead to severe pain evoked by barometric pressure changes.**[**35**]**

Moreover, increased corrosion of amalgam restorations was shown to be a result of the inhalation of pure oxygen, whereas, composite resins had low thermal shrinkage and maintained good adaptation to cavity walls and obstruction of dentinal tubules. Therefore, composite resins are more desirable for dental restorations in aircrew members to prevent barometric pressure–induced pain and tooth fractures. An additional protective cavity liner may also be effective in achieving a favourable outcome.

Periodic Examinations & Prevention

Early diagnosis of initial visible and occult oral disease is of special importance for aircrew members. However, there may not be uniformity in the frequency and extent of periodic dental examinations. Currently, there is no evidence-based guideline or particular consensuses regarding the frequency and extent of (periodic) aircrew's oral and dental examinations.

Conclusion

Flight safety, for medical preferences and even flight restrictions should be considered by the aviation dentist.Such in-flight conditions are often difficult to understand and diagnose, often presenting as a challenge to the dentist. The unusual nature of aerospace medicine requires practitioners who have unique expertise. Both dentists and aviators should gain awareness about aviation dentistry. This review describes such conditions and provides the dentists with some useful tools and guidelines.

Future Recommendations [36,37]

The knowledge and study of this field will open broader avenues in medical and dental science. This will even tend to be a promising field and department for the upcoming space missions in the future.Further on,thecourse in aeronautic dentistry should be included in the dental curriculumas wellas, a dedicated institute must be opened providing further education in this field with dedicated training, education and for further research.

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