

# Current concepts of oral and maxillofacial rehabilitation and treatment in aviation

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Aerospace medicine is the medical discipline responsible for assessing and conserving the health, safety, and performance of individuals involved in air and space travel. With the upward trend in airline travel, flight-related oral conditions requiring treatment have become a source of concern for aircrew members. Awareness and treatment of any potential physiological problems for these aircrews have always been critical components of aviation safety. In a flight situation, oral and maxillofacial problems may in fact become life-threatening clinical conditions. The unusual nature of aerospace medicine requires practitioners to have unique expertise. Special attention to aerospace medicine will open the way for professionals to develop and apply their skills and capabilities. Both dentists and aviators should be aware of the issues involved in aviation dentistry. This article presents the principles of prevention, treatment guidelines, and dental-related flight restrictions.

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**A**erospace medicine is the discipline that manages the “determination and maintenance of the health, safety, and performance of those who fly in the air or in space.”<sup>1</sup> Potential major problems can be induced by high speeds, altitude, low pressure, radiation, gravitational (G) forces, and movements in the 3 axes during flight.<sup>1,2</sup> Disorders caused by G-forces and fear of flying result in hypoxia, vertigo, air sickness, decompression illness (including barotitis, “the bends,” “the chokes,” and the expansion of gases in the abdomen), visual illusions, and jet lag. With the increasing popularity in airline transportation, flight-related oral conditions requiring treatment have increased in aircrew members.

Awareness and treatment of any potential physiological problems in aircrews have always been critical components of aviation safety.<sup>2</sup> It is important for cabin, cockpit crews, and air traffic controllers to consider the effects of significant unreported medical conditions on performance.<sup>2</sup> The aircrew is liable for the lives of the aircrew members and passengers during flight. Achievement of a consistently safe flight operation depends on both keeping the aircraft in good condition and maintaining the stability of each crew member’s health status. Incapacitation resulting from medical causes could imperil flight safety.<sup>3,4</sup> Over the last 60 years, records of dental and other oral problems leading to severe in-flight pain, vertigo, incapacitation, and premature cessation of flights have been collected, and guidelines have been published to achieve enhanced flight safety.<sup>5-8</sup>

The main purpose of the present article is to emphasize the prevention and treatment of possible conditions in the oral and maxillofacial region to which aircrews are particularly susceptible.

## Barotrauma and barodontalgia

*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, including the middle ear, paranasal sinuses, lungs, teeth, and skin.<sup>8</sup> Barotrauma may result in conditions such as external otitic barotrauma, barotitis media, barosinusitis, barotrauma-related headaches, dental barotrauma, and barodontalgia.<sup>8,9</sup>

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.<sup>2</sup> Pain associated with changes in atmospheric pressure is observed at 6000 ft (1829 m). Nevertheless, long-term flights at altitudes of more than 7000 ft (2134 m) are increasing in incidence.<sup>10</sup> Dental barotrauma is observed more often in military personnel than civilian air passengers or pilots.<sup>11</sup> Barodontalgia ranked fifth in physiological disturbances reported

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**Table.** Flight limitations for pilots according to US Federal Aviation Administration guidelines.<sup>4,5,16</sup>

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

by American pilots during flight and placed third in causes for premature descent in World War II.<sup>9</sup> During the 1980s, barodontalgia was reported in 0.26% of high-altitude chamber simulations in the German Luftwaffe.<sup>12</sup> Differential diagnosis of barodontalgia should include barosinusitis or barotitis media–induced pain, which is caused by pressure changes rather than pressure-related flare-ups of preexisting conditions.<sup>13</sup>

Many common oral pathologies have been reported as the main sources of barodontalgia. Zadik & Einy reported that pain during flight was caused by new restorations (26.9%), sinusitis (18.5%), and tooth or jawbone infections (18.5%).<sup>10</sup> Pulpal necrosis is responsible for 18%-36% of barodontalgia during flight.<sup>10</sup> In addition, parafunctional habits, such as clenching or grinding, may lead to periodontal disease or root fractures and create secondary barodontalgia.

Tooth pain may be severe enough to cause vertigo and incapacitation and may require premature cessation of hypobaric chamber training and flights.<sup>10</sup> Teeth that cause barodontalgia can be very difficult to detect, as barometric pressure changes cannot be replicated in clinical conditions. If detected early, pain due to barodontalgia is treatable. However, barodontalgia is frequently missed due to ignorance of the underlying conditions.<sup>9</sup> Therefore, all teeth with suspected pathosis should be subjected to annual clinical and radiographic examinations.<sup>15</sup>

## Tooth extraction

Extractions are performed for a wide variety of reasons, but most commonly to remove teeth that have become nonrestorable due to caries, periapical lesions, periodontal disease, or trauma; sometimes third molars causing recurrent infections are also removed. Some experimental studies have found that intraoral pressure changes occur during flight, adversely impacting the healing process in the early postextraction period.<sup>11,14</sup> These pressure changes can dissolve the blood clot that is developed within hours after a tooth extraction or other oral surgeries. Dissolution of the clot could result in excessive intraoral bleeding and interference with normal functions, particularly speech.

Additionally, after a posterior maxillary tooth is extracted, the site should be explored for oroantral communication; if it is present, referral to an oral surgeon for closure is indicated.<sup>15</sup> Oroantral communication can lead to sinusitis; thus, barometric pressure changes may evoke barosinusitis and barotitis media or cause other adverse outcomes.<sup>10</sup> The risk of developing emphysema can also increase as a result of a pressure-changing

environment.<sup>14</sup> 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.<sup>16</sup>

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 (Table).<sup>3-8,16</sup> In cases of oroantral communication, grounding should be advised until healing is evident, as changes in pressure can interfere with wound healing.<sup>15</sup>

## Odontogenic cysts or tumors

Barodontalgia can be caused by several common oral pathologies; however, barotrauma may be a clinical marker for early diagnosis of pathologies or abnormalities. Central or peripheral injury–induced neurologic impairments have been reported in the literature.<sup>16,17</sup> Macaluso & Galli reported a case of inferior alveolar nerve paresthesia created by barotrauma.<sup>18</sup> They found that barometric pressure changes also could cause rapid cyst expansion with loss of sensation.<sup>18</sup> The faster the altitude increased, the greater the increase in barometric pressure, leading to rapid cyst expansion. Sudden decreases in atmospheric pressure can cause transient inferior alveolar nerve compression, resulting in a long-term impact on the expansion of the cyst.<sup>10,18</sup> External pressure changes bring about temporary pressure on the sensory fibers of the alveolar nerve. These sudden pressure changes can cause capillary collapse, thereby depriving oxygen to nerves and blocking conduction. Experimental studies have found that a longer nerve compression interval results in a longer latency period before recovery.<sup>19</sup> Different airplane climb rates among different flights produce varying symptoms.<sup>18,19</sup> The faster the climb rate, the more rapidly a cyst expands.<sup>18,19</sup>

## Dental implants

Dental implants placed directly in the jaw allow for a fixed dental prosthesis. Dental implant rehabilitation is compulsory for German Air Force pilots due to the resultant improvement in phonation, nutrition, and feelings of well-being.<sup>10</sup> Degradation of personal performance and dietary deficiency (as a result of tooth loss and pain) may incapacitate an aircrew member for a flight. Thus, dental rehabilitation is considered to be an important issue in aviation medicine.<sup>10</sup>

In 2006, the Institute of German Aviation Medicine evaluated 45 pilots following their dental implant treatment and explained the standard process of dental implant rehabilitation in aviation.<sup>20</sup> The Institute declared that the decision of fitness for flight could be made only after wound healing had been completed without any complications and that aviators are under obligation to be rehabilitated with fixed prostheses specified by aviation medicine standards. The Institute reported that there were only 2 cases of implant failure and reimplantation was successful in one of those cases.<sup>20</sup> In the other case, the loss of the implant was related to histiocytosis.

Quality criteria that must be assessed after implants are placed in aviators include fixation, radiographic examinations, mucous membrane–gingival harmony, occlusion, and articulation.<sup>20</sup> 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.<sup>21</sup> A sinus lift bone grafting procedure improves the bone height in the posterior maxilla, making it more

suitable for implant rehabilitation. However, as stated previously, one of the most common flight-related disorders is barotrauma to the paranasal sinuses.<sup>2</sup> Therefore, flight restriction is required after maxillary sinus augmentation surgery due to pressure changes during flight.<sup>22</sup> Gases within the sinuses expand and escape through the sinus ostium as atmospheric pressure decreases during ascent. In addition, the ostium becomes obstructed as a part of a ball-valve effect, thus blocking air entry from the sinus during descent.<sup>22,23</sup> In this way, negative pressure occurs in the sinuses and causes pain and mucosal edema; in severe cases, the pressure may result in mucosal hemorrhage. Furthermore, individuals with prolonged tooth loss and severe pneumatization of the sinus suffer poor drainage problems. These patients complain of excessive drainage after lying down.<sup>23</sup> Prolonged irritation of the sinus membrane leads to granulomatous tissue formation, causing halitosis, an unpleasant taste in the mouth, and, in extreme cases, soft tissue polyps in the sinus cavity.<sup>24</sup> Thus, maxillary sinus augmentation surgery and dental implant rehabilitation of the aircrew should be managed by experienced oral and maxillofacial surgeons who are knowledgeable about flight physiology.<sup>25</sup>

### Bruxism

Bruxism is a parafunctional habit of excessive clenching of the jaw or grinding of teeth. 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 (TMJs).<sup>16</sup> Aircrew members experience a unique working environment that contributes to chronic stress, resulting in a variety of health problems.<sup>26</sup> 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.<sup>26</sup> Other work parameters, such as irregular shifts, have also been associated with bruxism. The long-term outcomes of bruxism are abrasion of teeth, periodontal problems, and dysfunction of the TMJ, accompanied by headache and facial myalgia, especially on arising in the morning. Studies have shown that bruxism is clearly more prevalent among pilots than nonpilots (69% and 27%, respectively).<sup>16,26</sup>

Various strategies have been used in the treatment of TMJ disorders. Combinations of pharmaceutical treatment (anti-inflammatory drugs, narcotic analgesics, and muscle relaxants) and physical therapy (physiotherapy, massage, acupuncture, and laser biomodulation) are usually the first phase of treatment for TMJ disorders.<sup>27</sup> Since some medications (such as analgesics) can cause dizziness or lack of concentration, the grounding of aircrew members should be considered when they receive such medication.<sup>16</sup> Surgery (including arthrocentesis, arthroscopy, and open arthrotomy) is the second choice of treatment if the patient does not benefit from pharmaceuticals.<sup>27</sup>

### Botulinum toxin injections

Botulinum toxin type A is a purified derivative of the toxin produced by the bacteria *Clostridium botulinum*, which acts by blocking neuromuscular transmission at motor nerve terminals, causing temporary muscle paralysis.<sup>28</sup> Botulinum toxin type A injections have been used for esthetic applications, such as masking a gummy smile, but they are also used in the treatment of focal dystonias, hypertrophies, parafunctions, and malfunctions of the salivary glands.<sup>28,29</sup>

The effectiveness of botulinum toxin injections as a new treatment option for bruxism has also been reported.<sup>26,28,30</sup> The aim of injections of botulinum toxin is to organize the relationship between the muscles that open and close the mandible as well as to optimize TMJ kinetics.<sup>28,31</sup> According to US Federal Aviation Administration (FAA) standards, botulinum toxin injections, if prescribed, would be allowed, and pilots and aircrews can return to flight after 72 hours.<sup>32,33</sup>

### Dental restorations and prosthetics

Early diagnosis of initial visible and hidden dental disorders is of special importance for aircrews. Air forces worldwide are nonuniform in the frequency and extent of periodic oral examinations; thus, there is no consensus on the optimum intervals of periodic oral and dental examinations of aircrews.<sup>34</sup> Rayman noted that the maintenance of dental health in aircrews prevents in-flight incapacitation resulting from oral disorders and the associated increased discomfort, decreased performance, and nutrition difficulties.<sup>7</sup> Panoramic radiographs could be useful for diagnosis of asymptomatic dental pathoses.<sup>8</sup>

Leaky dental restorations or recurrent carious lesions may cause dental fractures, also known as *odontocrexia*, under variable atmospheric pressure. Therefore, leaky or incomplete restorations should be repaired or replaced at the time of preflight dental examinations in order to prevent dental fractures.<sup>35,36</sup> Calder & Ramsey compared the decompression strength of composite resin and amalgam restorations and 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.<sup>35</sup> The authors also found that the unfavorable 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.<sup>35</sup> Moreover, increased corrosion of amalgam restorations was shown to be a result of the inhalation of pure oxygen. On the other hand, 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 in order to prevent barometric pressure-induced pain and tooth fractures. An additional protective cavity liner may also be effective in achieving a favorable outcome.<sup>36</sup>

Placement of a cuspal coverage crown is indicated for a severely damaged tooth. Lyons et al found that certain types of cement materials are more effective in aviation dentistry to ensure the longevity of treatment success.<sup>37</sup> Barometric pressure changes can impair the retention of dental restorations due to microleakage in the cements.<sup>37</sup> 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 cements.<sup>38</sup> Thus, use of resin cements should be preferred in aviation dentistry to ensure the retention of restorations and prevent dental pain by obstructing dentinal tubules and inhibiting microleakage. Use of a provisional restoration or temporary cementation is not recommended for aircrew members.<sup>37,38</sup>

Dental implants are the treatment choice for edentulous aircrew members, but many researchers consider bruxism to be an exclusion criterion for dental implant treatments.<sup>11</sup> The clinical management of bruxism, considered a major problem in aviators suffering from chronic stress due to a unique working environment, is becoming an increasingly important consideration in dental implants for aircrews.<sup>16</sup> Although there is no evidence regarding the preferred biomaterials for dental implants, it has been suggested that an implant made of titanium alloys, rather than an implant made of commercially pure grade I titanium, should be used for aircrew members suffering from bruxism.<sup>39</sup>

## Xerostomia

The relative physiological responses to chronic stress and workload under adverse environmental conditions can affect the chemical composition of saliva and its flow rate.<sup>40</sup> It has been determined that aircrew members have significantly increased levels of cortisol, potassium, and glucose in their saliva. These increases—which are used as indicators of emotional and physical stress—are affected by the aircrew member's flight experience and inflight task sharing.<sup>40</sup> Levels of immunoglobulin A in saliva (a potential marker of saliva water volume) were shown to significantly decrease during flight.<sup>41</sup>

Proper hydration is even more critical for mucosal immunity. 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.<sup>42</sup> Caries and periodontal diseases are potential long-term consequences of xerostomia.<sup>40</sup> Increased fluid intake is recommended to increase salivation and prevent dryness of the mouth. In severe cases, artificial saliva substitutes can be prescribed.

## Medications

Flight restriction of a patient is required when the flight capabilities of an aircrew member are compromised and pose an in-flight hazard. Unfavorable medical conditions as well as drug utilization may lead to incapacitation. Some medications, such as opiates, can cause dullness or poor concentration, whereas some antibiotics can cause diarrhea. Moreover, a medical condition requiring the use of antibiotics is a direct reason for grounding of aircrew members.<sup>16</sup> 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 half-life is not indicated, until 5 times the maximum recommended dosing interval has passed.<sup>43,44</sup> Aircrew should be informed about postoperative flight consequences and restrictions at the time their treatments are scheduled.

## Conclusion

For flight safety, both medical preferences and flight restriction times should be considered by the aviation dentist. The problems and challenges of treating these employees are quite different from those encountered in individuals who live and work only on the surface of the planet Earth. The unusual nature of aerospace medicine requires practitioners who have unique expertise. Both dentists and aviators should gain awareness about aviation dentistry. Special attention in any area of aerospace medicine will open the way for professionals to develop and apply their skills and capabilities.

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