

Barodontalgia

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Abstract

Although considered rare, dentists may encounter oral pain evoked by a change in barometric pressure, a condition known as barodontalgia (aerodontalgia). The article reviews the epidemiology, clinical presentation, pathogenesis, diagnostic process and differential diagnosis (including facial and dental barotrauma) of this phenomenon. Preventive measures are described as well. (*J Endod* 2009;35:481–485)

Key Words

Aviation medicine, aerospace medicine, compliance, decision making, dental caries, evidence-based medicine, military medicine, patient education, pulpitis

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With the increasing number of air passengers, airline and private pilots, and professional and leisure self-contained underwater breathing apparatus (SCUBA) divers, dentists may encounter related oral conditions that require immediate treatment. One of these conditions is barodontalgia. A complaint about dental pain in barometric change may face dental practitioners with a diagnostic challenge. Although rare, dental pain during flying or while diving has been recognized as a potential cause of an aircrew member or a diver suddenly becoming incapacitated, thus jeopardizing the safety of the affected person as well as others (1–3). This article reviews the literature regarding barodontalgia, its pathogenesis, diagnosis, and prevention.

Methods

The current study is based on scientific literature published in English regarding barodontalgia (and aerodontalgia) and facial and dental barotraumas. A Medline search using the PubMed bibliographic index as well as an Index Medicus hand search were performed to identify articles published between 1930 and 2007. The references lists of the found articles were searched to find relevant publications. No restrictions were placed concerning study design.

Definition

Barodontalgia is an oral (dental or nondental) pain caused by a change in barometric pressure in an otherwise asymptomatic organ (4). In a diving environment, this pain is commonly known as “tooth squeeze.”

The name of this dental pain was given the prefix “aero” (ie, aerodontalgia) and was reported for the first time as an in-flight physiologic and pathologic phenomenon at the beginning of the 20th century. In the 1940s, with the appearance of the SCUBA, many in-flight manifestations caused by barometric changes were found to be associated with diving as well. Consequently, the prefix was changed to “baro” (4).

The accepted classification of barodontalgia at present consists of four groups relating only to pulp and periapical conditions and symptoms (Table 1) (5), whereas the former classification, established in the 1940s, consisted of three groups and included pulp pathologies as well as other possible causes of barodontalgia such as barosinusitis, barotitis media, and partially erupted teeth (6).

Literature and Education

Most of the current knowledge with regard to barodontalgia was acquired from military aircrews in the 1940s (World War II era). At that time, barodontalgia as well as other oral manifestations as byproducts of flying were an issue for concern, and specialty training in aviation dentistry was offered (6). Yet, more than 6 decades later, there is a lack of knowledge in the literature regarding this issue. Moreover, barodontalgia is rarely and, if so, only briefly discussed in endodontic, oral pain, or emergency medicine textbooks (7–9). Despite the rarity of this phenomenon, barodontalgia is of interest for dental practitioners (10), but those who look for more relevant data need to rely on literature from several decades ago (11).

Epidemiology

Most of the existing data were derived from the military. Because civilian pilots and divers are usually subjected to less rapid maneuvers and extreme situations than their military counterparts, it can be assumed that they are less vulnerable to the pathologic consequences of rapid pressure changes.

TABLE 1. Classification of Dental-Induced Barodontalgia

Class	Cause	Symptoms
I	Nonreversible pulpitis	Sharp momentary pain on ascent
II	Reversible pulpitis	Dull throbbing pain on ascent
III	Necrotic pulp	Dull throbbing pain on descent
IV	Peri-apical pathosis	Severe persistent pain on ascent and descent

High Altitude and Flight Conditions

Barodontalgia was reported in 0.7% to 2% of the United States Army Air Force altitude-chamber simulations during the 1940s. During these simulations, barodontalgia ranked fifth among the physiological complaints of the trainees and third as a causative factor of premature cessation of the simulation (6). Between 0.23% and 0.3% of US Air Force trainees suffered from barodontalgia during altitude-chamber simulations in 1964 and 1965, respectively (3). Similarly, barodontalgia was reported in 0.26% of altitude-chamber simulations in the German Luftwaffe during the 1980s (12) and in 0.3% of Turkish Air Force flights in the last decade (13). In a retrospective study undertaken after World War II in the US Air Force, 9.5% of American aircrews reported one or more episodes of barodontalgia during their flights (6).

At present, it seems that occurrences of in-flight dental manifestations of pressure changes are relatively low (compared with the reported occurrences from the first half of the 20th century) because of the current pressurization of airplane cabins, high-quality dental care, and the improvement of oral health in the second half of the 20th century (3, 14). In the last decade, 2.4%, 8.2%, and up to half of 499 Spanish, 331 Israeli, and 135 Saudi Arabian and Kuwaiti Air Force aircrews reported at least one episode of barodontalgia, respectively (14–16). The rate of barodontalgia in the Israeli Air Force was about one case per hundred flight years (14).

Diving Conditions

Barodontalgia has been experienced on one or more occasions by 9.2% of 709 Australian and American SCUBA divers (17).

Clinical Presentation

The physiologic and pathologic phenomena related to barometric changes can occur during flights and dives as well as during mountain climbing and in hyperbaric chambers or other environmental pressure scenarios. In-flight barodontalgia was reported at altitudes of 2,000 feet (18) to 5,000 feet (12). As mentioned earlier, the pressurization of airplane cabins helps reduce the prevalence of barodontalgia. However, because the pressure inside airplane cabins corresponds to pressures at altitudes of 5,000 to 10,000 ft, barodontalgia still may occur during commercial as well as nonpressurized helicopters flights. Rapid ascent (eg, 4,000 ft/min), which is related to more acute circulatory changes than slower ascent (in which the physiologic mechanisms could compensate), is related to a higher occurrence rate of barodontalgia (19).

During dives, barodontalgia may occur at a water depth of 33 ft (18) to 86 ft (5). However, during flying, theoretically possible pressure changes range from 1 atmosphere (at ground level) to 0 atmosphere (at outer space); the changes are more significant during diving because each descent of 10 m (32.8 ft) elevates the pressure by another 1 atmosphere (2).

Whether the pain occurs during ascent or descent (in both flying and diving) depends entirely on the related pathology. Generally, pain

on ascent is related to vital pulp disease (ie, pulpitis) and pain on descent to pulp necrosis or facial barotrauma (ie, barometric related trauma to facial cavities, which will be described in the next sections). Pain related to periapical disease can appear during ascent as well as descent (20). Thus, most cases of barodontalgia happened during ascent (14). The nature of the pain also depends on the related pathology (Table 1) (4). The pain usually ceases when returning to onset level or ground atmospheric level but can last longer if caused by periapical disease or facial barotrauma (21).

Diagnosis

Previous studies have documented the difficulty of obtaining a definitive diagnosis of the causative pathology of barodontalgia (6, 22) because of the need to identify the offending tooth, which could be any tooth with existing restoration or endodontic treatment (often clinically accepted) and/or adjacent anatomical structures (eg, maxillary sinus). Moreover, practitioners cannot reproduce the pain trigger factor (ie, barometric pressure change) with ordinary dental facilities, and, even in a diagnostic altitude-chamber simulation (which has been offered as a diagnostic aid method [12]), it is sometimes impossible to reproduce the pain. Therefore, the history is of even greater importance. Data regarding recent dental treatments, on-ground preceding symptoms (swelling, sensitivity to cold, percussion, and so on), and pain onset/cessation (on ascent or descent) and the nature of the pain (sharp, dull, beating, and so on) can direct practitioners toward the offending tooth (Table 1). In addition, because a significant number of barodontalgia cases (up to 86% in one series [5]) involved teeth with faulty restorations, the presence or absence of a (faulty) restoration is a good starting point for dental examination.

Differential Diagnosis

Barodontalgia is a symptom rather than a pathologic condition itself. In most cases, it is an exacerbation of preexisting subclinical oral disease (10). Most of the common oral pathologies have been reported as possible sources of barodontalgia including dental caries, defective tooth restoration, pulpitis, pulp necrosis, apical periodontitis, periodontal pockets, impacted teeth, and mucous retention cysts (6, 12, 14, 23). Table 2 summarizes the most common conditions that were reported as causes of barodontalgia during high-altitude chamber simulations and flights (5, 6, 12–15, 23, 24).

In four exceptions, barodontalgia is not a symptom of a preexisting disease but of a pressure change–induced (new) pathologic condition. These conditions are facial barotraumas. The term facial barotrauma generally refers to barometric-related trauma to facial cavities, including barotitis media (middle ear barotrauma), external otitic barotrauma, barosinusitis (sinus barotrauma), and dental barotrauma. Barotitis media is a traumatic inflammation in the middle ear space produced by a pressure differential between the air in the tympanic cavity and that of the surrounding atmosphere. External otitic barotrauma is caused by injury to the lining mucosa of the external ear canal because of the airtight space between an object in the outer ear canal and the eardrum. Barosinusitis is an inflammation of one or more of the paranasal sinuses produced by the development of a pressure difference (usually negative) between the air in the sinus cavity and that of the surrounding atmosphere (3).

Referred pain from extraoral facial barotrauma (barotitis media, external otitic barotraumas, and barosinusitis) can be manifested as a toothache and should therefore appear in the differential diagnosis list of barodontalgia. Table 3 compares pulp/periapical-related (“direct”) barodontalgia and barotitis/barosinusitis-induced (“indirect”) barodontalgia. In contrast to some authors’ arguments that the

TABLE 2. Diagnosis of In-flight Barodontalgia in the United States, Canadian, German, Spanish, Israeli, and Turkish Air Forces and US Navy Reports

Diagnosis	US Army Air Forces 1944 (24) (%)	Royal Canadian Air Force 1945 (23) (%)	US Army Air Forces* 1946 (4) (%)	US Navy† 1982 (11) (%)	German Luftwaffe 1993 (12) (%)	Spanish Air Force 2004 (15) (%)	Israeli Air Force 2007 (14) (%)	Turkish Air Force 2007 (13) (%)
Recent restorative treatment	NI	5	+	NI	NI	NI	30	NI
Defective restoration	NI	NI	NI	NI	NI	23	NI	28
Deep caries without pulp exposure	NI	37	NI	NI	36	NI	NI	16
Vital pulp exposure	NI	17	+	NI	29	NI	NI	NI
Pulpitis	74	28	NI	64	14	NI	7	22
Pulp necrosis and/or periapical periodontitis	22	NI	+	36	14	39	19	22
Barosinusitis	3	NI	NI	NI	NI	NI	19	6

NI, not investigated.

*The 1946 United States Army study reported the most prevalent diagnosis without indicating exact percentages.

†The United States Navy reported that 21% cases occurred during diving, whereas 79% occurred during flying.

vast majority of barodontalgia cases are actually barosinusitis-referred pain (8, 25), in other studies, nondental facial barotrauma was found to be responsible for only 3% to 37% of barodontalgia cases (6, 12, 14).

Dental barotrauma refers to the dental mechanical alterations that relate to barometric pressure changes (eg, fracture of teeth [also called barodontocrexia], deterioration, and reduced retention of restoration) (26). This kind of fracture of tooth or restoration, like on-ground dental fracture, can be followed by pain (27).

Finally, in cases of oral pain during diving, dentists should rule out pain caused by the continuously forward-postured and clenched mandible (masticatory muscles contraction) needed to hold the breathing mouthpiece in position. There is a controversy whether SCUBA divers are at risk for temporomandibular dysfunction (28).

Pathogenesis

The extreme cold of a high-altitude environment (the temperature decreases about 2°C for every 1,000-ft ascent) and the cold oxygen pilots inhale were offered as possible contributors of in-flight toothache. However, in his study on the effect of flight temperature on teeth, Harvey (29) showed that an external temperature of -30°C to -40°C caused only a slight drop of tooth temperature to a minimum tooth temperature of 22.8°C in the lower canine (whereas pain was noticed only when tooth temperature was reduced to 12°C by iced water). Molar temperatures were even higher because of a shielding effect by the tongue and cheek. Harvey concluded that iced drinks would produce a lower tooth temperature than high-altitude flying (29). Moreover, high-altitude simulations, in which the environmental conditions can be regulated, served as another study platform. Because dental pain was reported during barometric change-only simulations, it was the only factor that could be contributed to the occurrence of pain.

Pulpitis is the reported main cause of barodontalgia. This includes postoperative barodontalgia, which may appear in a recently restored tooth (14). Postoperative barodontalgia is one of the most common types of in-flight barodontalgia (Table 2). Restorative dental treatment is known to have the potential to cause acute partial or total reversible pulpitis (30). Clinically, at ground level, a mild transient pain may or

may not be present. After approximately 1 week, acute pulp inflammation subsides and chronic inflammation ensues for several days to weeks (31).

During the 1940s, there were several suggestions to explain the pathogenesis of barodontalgia caused by pulp inflammation:

1. Direct ischemia resulting from the inflammation (6).
2. Indirect ischemia resulting from intrapulpal increased pressure as a result of the vasodilatation and fluid diffusion (32).
3. The result of intrapulpal gas expansion. The gas is a byproduct of acids, bases, and enzymes in the inflamed tissue (33).
4. The result of gas leakage through the vessels because of barometric-related reduced gas solubility. This theory, offered by Orban and Ritchey (34) during the 1940s, was based on a histologic view of gas bubbles on sectioned teeth that were extracted after barodontalgia. Bergin (35) accepted the solubility theory, but Lyon et al (36) rejected that theory because the authors had seen gas bubbles only in 6 out of 75 teeth. Another argument against the solubility theory is the possibility that the gas bubbles that they had seen were artifacts because of an inadequate fixation of the histological preparations (37).
5. Hyperemia in the pulp canal system caused by decompression. This theory was also offered by Orban et al (38) who studied dogs' teeth in 38,000 feet conditions.
6. Changes in barometric pressure in the case of defective restoration may force oral fluids to be sucked from the inner dentin tubules, thus causing sensitivity or pain in the pulp chamber. Moreover, defective restoration may cause pulp inflammation, causing barodontalgia indirectly. The old myth that pain is caused by "air that is trapped beneath a poorly filled dental cavity" and expands on ascent is still popular (9, 39), although unproven. During restorative treatments, Devoe and Motley (40) created "trapped air" under restorations in eight patients by placing a loose pellet of cotton in the cleansed pulpal floor of the cavity. The restorative material was then placed over the cotton. None of the patients reported pain in high-altitude exposures.

TABLE 3. Dental-Related (Direct) Versus Non-Dental-Related (Indirect) Barodontalgia*

Characteristic	Pulp disease-induced (direct) barodontalgia	Periapical disease-induced (direct) barodontalgia	Facial barotrauma-induced (indirect) barodontalgia
Cause	Pulp disease	Periapical disease	Barosinusitis, barotitis media
Appearance	During ascent Pain usually ceases during descent at the appearance-level	<i>Periapical periodontitis</i> : usually at high altitude (38,000 ft) during ascent or descent	During descent Pain usually continues on ground
Symptoms	<i>Nonreversible pulpitis</i> : sudden sharp penetrating pain <i>Reversible pulpitis or necrotic pulp</i> : dull beating pain	Continuous intense or dull beating pain swelling	Dental pain in maxillary molar or premolar region
Dental history	Recent dental work Recent dental thermal sensitivity (eg, during hot or cold drinking)	Recent dental percussion sensitivity (eg, during eating)	Present upper respiratory infection Past sinusitis illness
Clinical findings	Extensive dental caries lesion or (defective) restoration Acute pain upon cold (~-40°C) test	Extensive caries lesions or (defective) restoration Acute pain upon percussion test	Pain on sinus palpation Pain upon an acute change in the head position
Radiological findings	Pulpal caries lesions Restoration close to pulp chamber	Pulpal caries lesions Restoration close to pulp chamber Periapical radiolucency Inadequate endodontic obturation	Opacity (fluid) on the maxillary sinus image

*Data from references 3,10, and 18.

Currently, there is no consensus about the pathogenesis underlying pulp-related barodontalgia. However, a healthy pulp is unaffected by barometric change (4).

Regarding barodontalgia in endodontically treated tooth, it was offered that pain may be generated because of the expansion of trapped air bubbles under the root filling (18). Barodontalgia caused by periapical periodontitis or impacted teeth is probably caused by the elevated pressure within the bony lesion or tooth crypt, respectively (21).

Facial Barotrauma and Emphysema-related Barodontalgia

Barotitis media is the most common reaction of aviators to altitude-related pressure changes (3). In rapid descent, the negative pressure developed in the middle ear is usually not resolved spontaneously by the one-way fluttered auditory (Eustachian) tube. As a result, a partial vacuum is created, and barotitis media may result, with tympanic membrane retracting and, later, hemorrhaging as well as vascular engorgement occurring. The symptoms of barotitis media range from ear discomfort to intense pain, tinnitus, vertigo with nausea, and deafness (41, 42). The pain can be referred to the oral region (43). The management of barotitis media includes pressure relief by the Valsalva maneuver or altitude change. On-ground treatment includes antihistamine and systematic as well as topical decongestant. Resistant cases can be managed by systematic prednisone (40-60 mg/d for 4 to 7 days). Surgical perforation of the tympanic membrane is not a treatment of choice, unless there is an emergent need for flying (3).

External otitic barotrauma is mostly caused by the misuse of earplugs. During descent, the relative pressure in that closed cell is negative (compared with outer pressure); thus, the external layer of the tympanic membrane epithelium or of the external canal epithelium (or both) may be sucked away from the underlying tissue. Subepithelial hemorrhagic areas can then be formed. The process of stripping the epithelial layer may be accompanied by pain (3). Gibbons (44) reported external otitic barotrauma caused by expansion of air in earphones expressed as barodontalgia. The immediate management in case of external otitic barotrauma is the adjustment of the earplug (3).

Barosinusitis might occur when the normal sinus outflow is compromised, as may occur during upper respiratory tract inflammation, and 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, serosanguineous exudate, and submucosal hematoma, which may consequently cause pain, sometimes abrupt and severe, and possibly epistaxis (3). Similar to ground sinusitis, barosinusitis too can be referred to the oral region (15, 45). The management of barosinusitis includes decongestant nose drops, analgesics, and occasionally antibiotics (prevention of secondary infection) (3).

Changes in barometric pressure in case of a necrotic pulp with an open decayed crown, which permits the entrance of air to the pulp chamber, can cause the infected/inflamed root canal content to be forced into the jawbone (1, 46) and lead to facial emphysema (47). Robichaud and McNally (18) suggested that perforation in oral tissue (eg, after surgical procedure) can be prone to barodontalgia in aircrews and divers who wear oxygen masks because of air pushing into the tissues.

Prevention

The key feature in the prevention of barodontalgia is good oral health (18). During periodic dental examination, special attention should be given to defective (fractured or cracked) restorations, restorations with poor retention, and secondary caries lesions. Pulp testing and periapical radiographs should be performed in teeth with preexisting extensive restorations to rule out occult pulp necrosis. Panoramic or periapical radiographs of upper and lower incisors may be of diagnostic value for revealing additional occult dental pathologies (4). Some authors offered panoramic radiographs at 5-year intervals for people at risk for barodontalgia (18).

Although routine dental restorative treatment does not require grounding (4), recent restorative treatment was reported as a major cause of barodontalgia (Table 2). Therefore, 24 to 72 hours of grounding is an effective means for preventing postoperative barodontalgia. It is reasonable that ambulatory dental appointments should be scheduled for a date with a sufficient time interval before the next planned flight or dive. At the time of planning treatment, dentists must

notify their aircrew or diver patients and patients planning a flight or dive about the postoperative flight consequences and restrictions (48).

Rossi (49) recommends the grounding of military aircrews from the time of diagnosing the need for endodontic treatment until the treatment is completed. It is reasonable for an inexperienced dental practitioner to consult with a flight surgeon before recommending flight restriction to the aircrew patient (4).

Most of the previously published guidelines dictated a more interventional/nonconservative approach to treating aircrews for eliminating the potential of acute symptoms in flight (4). For example, in the World War II era, it was recommended that in aircrew patients all pulpless teeth were removed and metallic restorations replaced with nonmetallic (plastic) restorations "in order to minimize the pressure in the pulp chamber that may produce odontalgia" (50). Recently, although not evidence based, Rossi (49) contraindicated direct pulp capping in aircrew patients and recommended endodontic treatment in each case of suspected invasion to the pulp chamber in order to prevent subacute pulpitis or silent pulp necrosis and their potential barometric pressure-related consequences. During restorative treatment to aircrew or diver patients, after carious tissue is removed, the clinician has to carefully examine the cavity floor and rule out penetration to the pulp chamber. A protective cavity liner/base (with zinc oxide eugenol the chosen material) should be applied before the cavity is restored (4, 18).

Summary

This article reviewed the facts that are known about barodontalgia. Although it may seem that this issue was neglected in dental education and research in recent decades, familiarity with and understanding of these facts may be of importance for dental practitioners. Dentists should employ the described preventive measures when treating pilot and diver patients, and should use the data available for diagnosing the causes of barodontalgia.

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