Dental Barotrauma

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Purpose: The aim of this study was to review the current knowledge regarding dental barotrauma. ***Methods:*** A search using the PubMed Bibliographic Index and Index-Medicus was performed to identify articles in English that were published between 1930 and 2007. The reference lists of the resulting articles were searched to find publications relating to dental barotrauma. ***Results:*** Only a few scientific publications reported this phenomenon. Moreover, a significant part of the relevant literature was from more than 60 years ago. There was no published study on the current incidence rate of this phenomenon. ***Conclusion:*** Besides other oral manifestations of barometric pressure changes, such as barodontalgia (barometric pressure–related oral pain), a clinician should be familiar with this entity and take preventive measures as well as periodically examine his or her patients who fly planes or scuba dive. The clinician should also search for occult pathologies such as leaking restorations or secondary caries lesions. In addition, the clinician should be aware of the possible influence of pressure changes on the retention of prosthetic devices and plan treatment accordingly. *Int J Prosthodont 2009;22:354–357.*

Shortly after the innovation of flight at the beginning of the 20th century, in-flight physiologic and pathologic phenomena began to be reported. In the middle of the century, with the introduction of the self-contained underwater breathing apparatus (SCUBA), many of these manifestations, caused by atmospheric pressure changes, were described in association with diving as well. Of these phenomena were barometric pressure–induced tooth fracture, restoration fracture, and reduced retention of the restoration, called dental barotrauma.

Neither a review nor textbook chapter is available on this subject for dental practitioners who treat patients that are exposed to pressure changes (ie, professional or leisure pilots, divers, parachuters). This article reviews the current knowledge regarding dental barotrauma.

Methods

This study is based on scientific literature published in English regarding dental barotrauma. 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 reference lists of the resulting articles were searched to find relevant publications. No restrictions were placed concerning study design. Generally, only a few scientific publications reported this phenomenon. Moreover, a significant part of the relevant literature is from at least 60 years ago. There was no published study on the current incidence rate of this phenomenon.

Boyle's Law and Barotrauma

Barotrauma is a pathologic response to changes in barometric pressure that occur during flying, diving, or hyperbaric oxygen therapy.[1] According to Boyle's Law, the volume of gas at a constant temperature varies inversely with the surrounding pressure. The gas pressure–volume changes inside the body's rigid cavities, associated with the changing atmospheric pressure, can cause inflammation or other adverse effects, known as barotrauma.[2] In the orofacial region, barotrauma is manifested either as facial barotrauma (eg, barosinusitis and barotitis-media) or dental barotrauma. Dental barotrauma can manifest itself as tooth fracture, restoration fracture (both will be referred to in this article as dental fracture), and reduced retention of the restoration.

Similar to dental fracture incurred at ground level, dental barotrauma can appear with or without pain.[3]

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In case of accompanied pain, it can be defined also as barodontalgia, or barometric pressure–induced dental pain.[4,5]

In-flight Dental Fracture

Several reports, mostly from the World War II (WWII) era, deal with the fracture of restorations during high-altitude flying.[6–8] In a symposium of aviation dentistry held in 1946 to summarize the United States Air Force (USAF) experience during WWII, in-flight "loss of fillings" was one of the discussed conditions. The symposium confirmed that the loss of restorations actually occurred during high-altitude flight.[7]

Among the first to report on this subject were Armstrong and Huber, who in 1937 published the results of a 7-month clinical observation of a small group of five pilots with 200 to 3,750 hours of flight per subject at 10,000 to 40,000 feet (and a comparison group of five nonpilots). Among the five pilots, the authors found that one silicate restoration washed out.[6]

Sognnaes[8] described a series of 17 cases of dental barotrauma among fighter pilots during WWII. Of the 17 aircrews, there were six cases of restoration fracture, six of lost restorations, and five of loosening restorations. The accompanying symptoms included a dull toothache in one subject and sensitivity to cold in another. The author emphasized that all six cases of restoration fracture were attributed to high altitudes and barometric pressure changes; two were combined with simultaneous exposure to cold and oxygen inhalation. The six cases of lost restorations occurred at high altitude/low barometric pressure, whereas two also occurred in a low temperature environment. Similarly, four of the five cases of restoration loosening were attributed to altitude and pressure, whereas one case could not be attributed to these factors, only to acceleration. Overall, of the 17 damaged restorations, 14 were attributed to high altitude/barometric pressure changes.[8]

Although most of the reported dental fracture phenomena date from several decades ago, this can occur even under current flight and simulation conditions.[3] Zadik et al described two cases: the first of molar fracture in an 18,000-foot uncompressed flight, and the second of restoration fracture in a 25,000-foot high-altitude chamber simulation.[3] However, the current incidence of the phenomenon is unknown.

In-diving Dental Fracture

Similar to the situation during flight, in-diving dental barotrauma also occurs while ascending. Upon returning to the surface after completing the dive, the diver may report that a tooth has broken or shattered.[9]

In a 10-year longitudinal study that was conducted in the German Navy, there was a fourfold increase in missing teeth and a 10-fold increase in crown placement among navy divers who were constantly exposed to barometric changes (200 to 300 annual hours of underwater diving), in comparison to an almost threefold increase in missing teeth and a fivefold increase in crown placement among submariners who usually served under normal pressure conditions.[10] These authors concluded that increased exposure to barometric stress was associated with elevated dental deterioration.[11]

Contributing Factors

Besides changes in barometric pressure, several contributing factors were offered as explanations for the increased incidence of in-flight dental fractures.

Parafunction

The 1946 USAF symposium on aviation dentistry proposed excessive occlusal force as a factor in dental restoration dislodgement. Excessive occlusal forces are associated with the tension of masticatory muscles when counteracting the effects of flight maneuvers.[7] Similarly, Sognnaes,[8] in a study on damaged amalgam restorations among fighter pilots during WWII, suggested that in-flight clenching/grinding of teeth was a major causative factor for restoration failure. In a 2007 study conducted in the Israeli Air Force, Lurie et al reported a significantly higher prevalence of bruxism among young military aircrews in comparison with their nonpilot counterparts.[12] In divers, oral snorkeling devices can contribute to the abrasion of teeth.[9]

Low Temperature

The extreme cold of a high-altitude environment and the cold oxygen pilots inhale may cause up to a 2.5-fold differential thermal contraction of the amalgam material compared with hard tooth tissue.[13] In his study on the effect of flying temperature on teeth, Harvey[14] showed that an external temperature of –30°C to –40°C caused only a slight drop in tooth temperature to a minimum of 22.8°C in the mandibular canine. Molar temperatures were even higher due to the shielding effect of the tongue and cheek. Harvey concluded that iced drinks would produce a lower tooth temperature than high-altitude flying. Therefore, contraction and expansion of metal restorations should not be more prevalent among high-altitude aviators than the general population.[15] It seems unlikely that cold temperature is the dominant mechanism underlying dental fracture.

Increased Oxygen Percentage

Oxidation during pure oxygen inhalation may cause electrochemical corrosion of the dental amalgam restoration.[13,16] However, no changes were noticed in extracted teeth after applying environmental changes in pressure and exposure to pure oxygen in vitro.[6]

Acceleration

One case in Sognnaes' series of in-flight restoration loosening was attributed to acceleration.[8] There is no additional discussion about this factor's influence on oral tissue in the current literature.

Dryness

Hyposalivation and dry mouth are well-established risk factors for the development of caries lesions.[17] Breathing dry compressed gases (air for most divers and oxygen for pilots) may cause dry mouth. However, there are no data regarding the influence of this temporary intraoral dryness and development of caries lesions and/or failure of restorations.

In Vitro Models

Seventy years ago, Armstrong and Huber investigated extracted innocent molars. Five molars served as the control group and five served as the experimental group. The teeth in the two groups were subjected to similar cavity preparation and restoration using different materials (eg, amalgam, gold, porcelain). The experimental group was exposed to a series of barometric pressure reductions (up to a pressure equivalent of an altitude of 40,000 feet), a pure oxygen environment, and cold temperature (down to −50°C). No change was noticed in either teeth or restorations of the control or the experimental group.[6]

However, in 1946, Sognnaes evaluated the discrepancy between the results of in vitro examinations, as well as decompression chamber simulation/training (in which it was difficult to observe a significant number of dental fractures), and the reported in-flight dental fracture by pilots.[8]

Calder and Ramsey[18] reported on an in vitro decompression study on extracted teeth. They applied a pressure drop of 1,035 kPa (approximating standard diving pressure) to ground atmosphere pressure on 86 extracted teeth within a 2-minute time period. Five of the studied teeth were damaged. All damaged teeth had either poor-quality amalgam restorations with undesired clearance between the tooth and the amalgam, or secondary caries under the restoration. The 81 nondamaged teeth included unrestored teeth with caries lesions. The authors concluded that the main predisposing factor for tooth fracture was a leaking restoration, rather than caries.

Reduction in Prosthetic Device Retention

Pressure changes in microscopic air bubbles in the cement layer underneath crowns can lead to a significant reduction in the prosthetic device's retention and can even lead to dislodgement,[9] especially if the crown was cemented with zinc phosphate cement.[19–21]

Lyons et al studied the effects of cycling environmental pressure changes (up to 3 atm) on the retention of crowns to extracted teeth. The crowns that were cemented with either zinc phosphate or glass-ionomer cement had significantly reduced retention (in approximately 90% and 50% of cases, respectively), whereas crowns that were cemented with resin cement were not subjected to reduced retention after pressure cycling.[20] Moreover, microleakage was detected in the zinc phosphate and glass-ionomer cements after pressure cycling, whereas no microleakage was detected in the resin cement.[21]

Reduced barometric pressure can impair the retention of removable complete dentures. However, whereas environmental pressure is a definite factor in the retention of maxillary dentures, it plays only a partial role in mandibular denture retention, in which a 70% decrease in pressure produced a 50% loss in retention.[22]

Discussion

Besides other oral manifestations of barometric pressure changes,[4,5,23] the clinician may encounter dental barotrauma, either in pilots or divers. There are only a few scientific publications on dental barotrauma, mostly from the first half of the 20th century. Moreover, all the information was derived from military populations. Currently, there is no knowledge regarding dental barotrauma among civilian air passengers/pilots or scuba divers. However, since 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.

It seems that currently, the incidence of in-flight dental barotrauma is relatively low compared to reported incidences from the first half of the 20th century, owing to the current inside compression of airplane chambers. The pressure inside the chamber fits pressures at altitudes of 5,000 to 10,000 feet, whereas cases of dental barotrauma were reported in pressures at altitudes of 18,000 feet and higher.[3] However, whereas in flight the theoretically possible pressure changes range from 1 atm (at ground level) to 0 atm (at outer space), in diving the changes are more significant, since each descent of 10 meters (32.8 feet) elevates the pressure by 1 atm. Thus, the barometric changes during diving may be more significant and responsible for more frequent and/or severe related pathologies than in-flight barometric changes. However, while aviators are obligated to be examined periodically,[24] it is a rarity among divers. Divers and aircrew medical examiners should recommend their aviator and diver patients to be periodically examined by a dental practitioner who is familiar with this subject.

The predisposing factors that constantly appear in dental barotrauma reports[3,8] as well as in vitro studies[18] and theoretical discussions[6] were preexisting leaking restorations and/or occult secondary (remaining or recurrent) caries lesions underneath restorations in the affected teeth prior to exposure to the barometric changes. The destructive potential of arrested or remaining caries lesions in daily life is minimal. Since the lesion is not active, progression toward the pulp tissue is unlikely.[25,26] Nevertheless, as Sognnaes suggested,[8] it seems that these lesions may not be so innocent in a pressure-changed environment.

Owing to the reduced retention, rehabilitation of missing teeth by removable prostheses should be avoided in the pilot/diver patient. However, removable prostheses should be removed before diving unless they are securely retained.[9] Patients should be advised not to dive while having provisional restorations or temporary cement in the mouth.[19] Resin cement should be used when treating patients who are subjected to pressure changes.[20]

Odontocrexis (Greek for "tooth explosion") is the term offered for describing the physical disruption of teeth due to barometric pressure changes (ie, dental barotrauma).[9,18] However, it seems that *barodontocrexis* more appropriately describes this phenomenon, since it evaluates the role of barometric pressure in the pathophysiology of the phenomenon. Moreover, *barodontocrexis* has the same form as other phenomena that are induced by barometric pressure changes (eg, barotrauma, barodontalgia, barosinusitis).

Conclusions

Although dental barotrauma is currently quite rare, a clinician should be familiar with this condition. Clinicians should be prepared to take preventive measures as well as periodically examine patients who fly planes or scuba dive. Leaking restorations or secondary caries lesions must also be taken into account. In addition, clinicians must be aware of the possible influence of pressure changes on the retention of removable prostheses and plan treatment accordingly.

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