Dental Fractures on Acute Exposure to High Altitude


There is little in the literature on dental restoration breakage in the aviation environment since reports of problems in combat aviators in War World II. We report two cases of dental fractures during acute exposure to a hypobaric environment. Case 1 was a young officer who suffered an amalgam restoration breakage during a 25,000-ft decompression chamber simulation. Case 2 occurred in an experienced aviator who had a tooth cusp fracture in a molar with a defective amalgam restoration during an unpressurized helicopter flight to 18,000 ft. In both cases, after removing the defective fillings, deep secondary caries were found; both teeth were successfully restored. Because hard-tissue tooth fracture during a high-altitude flight is a rare event, few flight surgeons or dentists are familiar with this phenomenon. We recommend regular dental examinations with careful assessment of previous dental restorations in aircrew subject to decompression.

Keywords: aviation dentistry, barodontalgia, decompression, secondary caries, odontocresis.

THE FLIGHT ENVIRONMENT and the flying profession may affect the jaws, oral tissues, and dental restorations. Such effects include tooth wear and periodontal diseases (6,10), decreased retention of prosthetic devices (14), barotitis media (7), and barodontalgia, a toothache due to barometric changes (6,7,10,11). Previous publications, mostly from the period of World War II, deal with dental restorations breakage during high-altitude flight (1,10,15). There are three high-altitude flight environmental factors that have been believed to cause in-flight dental restoration breakage:

1. Decreased barometric pressure: an air void embedded in a dental restoration explodes during barometric pressure changes (1). Although popular, this theory lacks scientific evidence.
2. Increased oxygen percentage: oxidation during pure oxygen breathing may cause electrochemical corrosion of the dental amalgam restoration (2,16).
3. Low temperature: the extreme cold of the high-altitude environment and the cold oxygen inhaled may cause differential thermal contraction, up to 2.5 fold, of the amalgam material compared with hard tooth tissue (2).

Armstrong and Huber (1) reported in 1937 that none of the above three factors harms teeth or dental restorations. In a 7-mo clinical observation on a small group of 10 pilots, the authors did not find any restoration breakage after 200 to 3750 h of flight per subject at 10,000 to 40,000 ft (1). Moreover, an in-vitro study by the same authors did not find any change in extracted teeth after applying barometric pressure changes and exposure to pure oxygen and to cold temperatures (1).

The USAF symposium of aviation dentistry held in 1946 proposed excessive biting forces as a fourth factor in dental restoration dislodgement. Excessive bite forces are associated with the tension of masticatory muscles when counteracting the effects of flight maneuvers (10). Similarly, Sognnaes (15), in a study of amalgam restoration breakage in combat flights during World War II, suggested that in-flight bruxism was the main factor for restoration failure. However, it was not reported whether these restorations were faulty before flight or whether carious lesions were seen beneath the broken amalgams, but the author concluded that the secondary carious lesion underneath the restoration was one of the factors of this in-flight phenomenon.

Calder and Ramsey (3) reported on an in-vitro decompression study on extracted teeth. Tooth structure fractures are more significant than restorations breakage, since the tooth may be irreversibly damaged. These authors applied a pressure drop of 1035 kPa to ground atmosphere pressure within 2 min on 86 extracted teeth. Five of the studied teeth were damaged. All the 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 non-damaged teeth included unrestored teeth with carious lesions. The authors concluded that the main predisposing factor for tooth fracture was leaking restoration rather than caries.

To our knowledge, Calder and Ramsey’s study (3) is...
the only published study on tooth fractures due to a high-altitude environment. They have coined the term “odontocresis” (Greek for tooth explosion) to describe this physical disruption of teeth with leaking restorations due to barometric pressure change. We report two cases of dental fractures in a decompressed environment: the first, a case of restoration breakage; and the second is a case of tooth fracture.

CASE REPORTS

Case 1

A 21-yr-old healthy asymptomatic officer underwent high-altitude chamber flight simulation for the first time in her life. The highest altitude in this flight simulation was 25,000 ft. On descent, she felt a left earache. Immediately after the simulation, left barotitis media was diagnosed by her flight surgeon. With instruction, the officer was able to balance the inner-ear pressure. Subsequent to the rapid improvement of her earache, a dull toothache was felt. The toothache was located on the left side of the upper dental arch. A week later, she was still complaining of a constant dull pain, and consulted with our dental clinic.

Dental examination revealed a broken leaking amalgam restoration on tooth #26 (left upper first molar; Fig. 1A). In a routine dental examination 6 wk before, this restoration was completely intact. The officer denied bruxism and no abnormal wear facets were seen on the affected tooth or the other teeth.

After applying lidocaine local anesthesia, the old amalgam restoration was removed. The restoration had an accepted isthmus width. A small carious lesion was revealed under the old restoration (Fig. 1B). The lesion was curettaged and the tooth was restored with a layer of calcium hydroxide (Dycal®, Dentsply Caulk Inc., Milford, DE) followed by amalgam (Tytin®, Kerr Dentistry, Romulus, MI). The officer has not suffered from toothache since then. No further decompression simulations were taken by the officer because the risk of barotitis media.

Case 2

A 41-yr-old Israeli Air Force experimental pilot underwent an unusual uncompressed 18,000-ft flight in a Sikorsky CH-53 helicopter. The temperature inside the non-air conditioned chamber was −10°C. While maintaining an altitude of 18,000 ft for 15 min, the pilot felt his upper right posterior tooth break. The pilot did not experience toothache before, during, or after that flight.

Dental examination revealed that the disto-buccal cusp of tooth #17 (right upper second molar) was broken (Fig. 2A). The tooth had had an amalgam restoration and responded normally to a vitality test. Unfortunately, pre-operative radiographs do not exist. The pilot denied parafunctional jaw habits such as teeth grinding or clenching generally and during that flight specifically. No occlusal surface wear signs were apparent (Fig. 2A). Under lidocaine local anesthesia, the old amalgam was removed. An extensive dental carious lesion was seen underneath the original restoration (Fig. 2B). The dental decay was removed. A layer of calcium hydroxide and a thick zinc-oxide-eugenol base (IRM®, Dentsply Caulk Inc., Milford, DE) were applied. Finally, the tooth was restored with amalgam. The pilot continues his aviation duties without dental symptoms.

DISCUSSION

It has been suggested that aircrew members are vulnerable to several flight-induced oral pathologic conditions such as barodontalgia (6,7,10,11), and dental restorations breakage (5,15). The last condition was described and investigated mostly in the World War II era. Decreased barometric pressure, a pure oxygen environment, extreme low temperature, and excessive biting force were proposed as the possible etiologic factors, but were not proved scientifically as the causes for...
Barodontalgia, a toothache produced during barometric pressure changes, is another third possible entity for dental pain that masked the onset of the dull dental pain. This phenomenon. Dental restorations breakage occurred during the World War II era, during a period before airplane compression. Tooth structure fracture of dental hard tissue caused by barometric pressure changes has similar dental aviation pathology, but is more severe. This pathology, induced exclusively in teeth with defective amalgam restorations, was described only in vitro in the 1980s by Calder and Ramsey (3), who offered the term “odontocresis.”

The subject in Case 1 suffered from a sharp barotitis media pain that masked the onset of the dull dental pain during decompression simulation. Subsequent dental examination and treatment of a broken amalgam restoration alleviated the dental pain. In this case, the only relevant environmental condition was the rapid drop of the environmental pressure. Barosinusitis, which can mimic pulpal symptoms, is another entity to be considered as a differential diagnosis. Since radiographs were not taken, possible molar root proximity to the maxillary sinus was not seen. However, immediately after the simulation, her flight surgeon ruled out barosinusitis based on clinical signs and symptoms. Barodontalgia, a toothache produced during barometric pressure changes, is another third possible entity for that case. The incidence of barodontalgia during World War II was up to 1% to 8% of the military flights and 9.5% (10) of American aircrews reported at least one episode of barodontalgia. Barodontalgia was diagnosed in 0.23–0.3% of cases in the 1960s (7) and 1990s (11) in high-altitude chamber simulations. However, in both cases described here, no such pain was observed, so barodontalgia is probably not the correct diagnosis.

Regarding the second case, the helicopter pilot felt his upper right posterior tooth break during an uncompressed 18,000-ft flight. Here, two environmental factors were relevant; that is, the low barometric pressure at 18,000 ft and the low ambient temperature as well as the low temperature of inhaled oxygen. Because of the three-dimensional irregular structure of the restoration, it was not possible to calculate the exact force applied or the thermal expansion of the tooth and restoration.

A routine “cold test” performed in the dental office for diagnosis of the dental-pulp condition applies a temperature of \(-77.7^\circ C\) on the tooth for 5 s (4). This test rarely causes fracture of teeth or restorations. In his study on the effect of flying temperature on teeth, Harvey (8) showed that an external temperature of \(-30^\circ C\) to \(-40^\circ C\) caused only a slight drop of the teeth temperature to a minimal tooth temperature of 22.8°C in the lower canine. Molar temperatures were even higher because of shielding from the tongue and cheek. Harvey concluded that iced drinks would produce a lower teeth temperature than high-altitude flying. Therefore, contraction and expansion of metal fillings should not be more prevalent among high-altitude aviators than the general population (9). In Case 2, the cockpit temperature was \(-10^\circ C\) and the oral cavity temperature was unknown, but probably higher than 0°C. It seems unlikely that the cold temperature was the dominant mechanism of the tooth fracture.

In both cases, carious lesions were found underneath the amalgam restorations. This observation is consistent with Calder and Ramsey’s (3) conclusion that pressure-induced breakage of teeth occurs only in cases of teeth with defective restorations and latent caries prior to exposure to the barometric changes. It is possible that the dental carious lesions underneath the old restorations were untreated primary caries. That is, the dental surgeon might not have removed all the diseased tissue at the initial tooth restoration (13). Another possibility is that of secondary caries due to acid-producing oral bacteria penetrating between a leaking restoration and the tooth wall. Our cases did not allow for distinguishing between primary and secondary carious processes, although the texture and black color (Fig. 1B, Fig. 2B) of the lesions suggest arrested carious lesions (12). The destructive potential of arrested carious lesions in daily life is minimal. Since the lesion is not active, progression toward the pulp tissue is unlikely. Nevertheless, as Sognnaes suggested (15), it seems that such lesions carry dangers in the aviation environment.

In conclusion, both cases had faulty restorations with latent carious lesions. Flight surgeons and dentists need to be aware of flight-related dental phenomena. Although dental breakage seems rare in the aviation environment, it may be prevented by regular dental examinations with adequate attention to existing dental restorations. The flight population would be better served by a more comprehensive understanding of the
issues, and an awareness of the limitations of our current knowledge base.

REFERENCES