Barodontalgia as a Differential Diagnosis: Symptoms and Findings

• **Roland Robichaud,** BSc (Hon) •
• **Mary E. McNally,** MSc, DDS, MA •

Abstract

This paper provides a review of the literature concerning the etiology and manifestations of barodontalgia, as well as important clinical considerations for its management. Barodontalgia is characterized by exposure to a pressure gradient, such as that experienced by underwater divers, aviation personnel and air travellers. This form of dental pain is generally marked by a predisposing dental pathology such as acute or chronic periapical infection, caries, deep or failing restorations, residual dental cysts, sinusitis or a history of recent surgery. Studies indicate that severity of barodontalgia and the resulting deterioration of dental health correlates with duration of barometric stress. Restorative materials are also affected by pressure gradients. Resin is indicated as a luting agent of choice for cementing fixed prostheses in populations at risk for barodontalgia. Under the influence of pressure gradients, resin cements maintain original bond strength and demonstrate the least amount of microleakage compared with other cements. The key to avoiding barodontalgia is good oral health. Clinicians must pay close attention to areas of dentin exposure, caries, fractured cusps, the integrity of restorations and periapical pathology in those at risk. The Fédération dentaire internationale describes 4 classes of barodontalgia based on signs and symptoms and provides specific and valuable recommendations for therapeutic intervention.

MeSH Key Words: *aerospace medicine; barotrauma/complications; diving/injuries; toothache/etiology*

This article has been peer reviewed.

During World War II, tooth pain experienced by air crew in flight was given the name *aerodontalgia*. However, as this tooth-related pain was also observed in divers, a broader, more appropriate term, *barodontalgia*, was subsequently given to this phenomenon.[1] Barodontalgia, which affects air crew and aircraft passengers as well as underwater divers, is pain or injury affecting teeth due to changes in pressure gradients.[2] Boyle's Law, which states that "at a given temperature, the volume of a gas is inversely proportional to the ambient pressure," may be used to explain barodontalgia.[2] Specifically, as a person descends deeper and deeper below the water surface, pressure exerted on the diver by the water increases and reduces the volume of gases in enclosed spaces such as teeth and sinuses. The same law applies if a person climbs to high altitudes (in flight); in this case, outside pressure decreases, permitting the volume of gases to increase. A problem arises when the enclosed spaces containing gases cannot expand or contract to adjust the internal pressure to correspond to the outside pressure. Aircraft personnel and passengers travelling in non-pressurized cabins are especially at risk.[2]

The importance of understanding, preventing and, where necessary, treating barodontalgia is especially evident when considering pilots of high performance aircraft. A study using a pressure chamber as a flight simulator revealed that in some instances barodontalgia was severe enough to affect flight safety.[3] In the past, barodontalgia was especially problematic for travellers during military flights where cabins were not sufficiently pressurized. Currently, and of particular relevance to the general public, are effects occurring during normal commercial flights and recreational diving. These range from a simple sharp or squeezing tooth pain to rupture of the alveolar mucosa.[2] The phenomenon begins to occur at an altitude of approximately 3,000 m and at a water depth of 10 m where the ambient pressures are 0.75 and 1 atmosphere, respectively.[4]

Etiology

The cause of barodontalgia has been investigated for many years. Kollman[3] refers to 3 important hypotheses to explain this phenomenon: expansion of trapped air bubbles under a root filling or against dentin that activates nociceptors;

stimulation of nociceptors in the maxillary sinuses, with pain referred to the teeth; and stimulation of nerve endings in a chronically inflamed pulp. He strongly supports the last 2 hypotheses and states that, for the latter, histologic evidence shows that chronic pulpal inflammation can still be present even when a thin dentin layer covers the pulp, for example, as in a deep cavity preparation.

Most cases of barodontalgia are associated with teeth already affected by some sort of pathology.[1] Clinically, people affected by barodontalgia were found to have one or more of the following: acute or chronic periapical infection, caries, deep restorations, residual dental cysts, sinusitis and a history of recent surgery.[5] The latter is of particular concern for people wearing oxygen regulators when diving using self-contained underwater breathing apparatus (scuba) or when wearing oxygen masks during high-performance aircraft flights due to the risk of air being pushed into the tissues. Sinusitis may also contribute to barodontalgia, although it may not be related to any tooth pathology. For example, Holowatyj[1] described a patient as having pain in his left infraorbital area, as well as in the maxillary left canine and maxillary left first molar during both a commercial flight and while flying a Tutor jet trainer. Although no tooth pathology was present, the patient did have mild congestion in his left maxillary sinus, with referred pain in his maxillary teeth. Barosinusitis is distinguishable from barodontalgia, as the former will always occur on descent, whereas the latter always begins on ascent.[5] Recognizing that symptoms only appear to arise in teeth (or sinuses) affected by some type of pathology, researchers concluded that a pressure gradient is a contributing factor, not the actual cause of the problem.[2]

Calder and Ramsey[6] tested whether large, rapid pressure changes generated within a capsule would create visibly detectable damage to extracted restored and nonrestored teeth. Of 86 extracted teeth subjected to the high-pressure environment, only 5 showed visible evidence of trauma. However, all 5 had inferior-quality restorations (i.e., deteriorating or leaking restorations present before extraction or placed after extraction). None of the unrestored teeth, regardless of the presence of caries, suffered any damage, suggesting that failing restorations play a major role in the occurrence of physical damage.

Underwater Diving

Scuba diving is one of the fastest growing sports in the world.[7] Thus, it is important for dentists to be aware of dental-related problems that may arise for scuba divers. The most common way for air from the pressurized tanks to enter a tooth is by being forced in through carious lesions or defective margins.[7] As atmospheric pressure decreases during ascent, trapped gases may expand and enter dentin tubules, thereby stimulating nociceptors in the pulp or causing the movement of pulp chamber contents through the apex of the tooth, also causing pain.[7]

In their study, Calder and Ramsey[6] mention that the physical properties of the gas mixture used during deep sea diving may contribute to barodontalgia. In scuba tanks, oxygen's natural diluent gas, nitrogen, is replaced by helium, resulting in a gas of lower viscosity. This gas can enter tissues, including teeth, and can sometimes become trapped in closed spaces, such as the pulp chamber and root canal. There are 2 mechanisms by which gases can be trapped in spaces: if there is a space between a tooth and its restoration, gas may be forced into it during an increase in pressure; and dissolved gas may diffuse from tissues into spaces as pressure decreases. Consistent with Boyle's Law, trapped gas will expand and the resulting stress may cause tooth fracture. This process has been called *odontecrexis*, a Greek word meaning tooth explosion.

Physical Manifestations

Although understanding the etiology of barodontalgia is of great importance, its physical manifestations also deserve some attention. In their study, Goethe and coworkers[8] attempted to identify early and late damage due to barodontalgia by examining 50,000 tooth-related clinical problems (e.g., carious lesions, tooth trauma, deteriorating restorations) at the Nautical Medical Institute of the German Navy at Kiel. Among these findings, 13,618 were from 2,580 navy divers, frogmen and submariners. The patients were divided into 2 categories: those working under normal atmospheric pressure (1,291 submariners) and those working under changed atmospheric pressure (1,289 divers and frogmen). Navy divers spend an average of 200–300 hours a year under water whereas frogmen usually spend longer times at shallower depths.

An initial examination revealed that overall, divers and frogmen had better oral health than submariners. Dental findings were reviewed at 3, 6, and 9 years. At 9 years, deterioration in the teeth of navy divers and frogmen had occurred at significantly higher rates than those of the submariners in terms of missing or crowned incisors, canines, premolars and molars. More specifically, although they were healthier at baseline, frogmen were in the poorest state of dental health after 9 years, surpassing even the navy divers. This suggests a correlation between the deterioration of dental health and increased exposure to barometric stress.

To further support these results, another longitudinal study[8] was conducted on navy divers and submariners from the time of their entry into the navy until they had served for more than 10 years. Once again, the dental health status of navy divers was initially slightly better, but after 10 years, they demonstrated a 300% increase in missing teeth and a 900% increase in the placement of crowns. The submariners' examination at 10 years revealed an increase of only 186% missing teeth and 375% crown placement. These findings confirm that navy divers' teeth have a faster rate of deterioration than submariners'. Again, this is attributed to higher levels of barometric stress.

Dental Materials

We have described the signs and symptoms of barodontalgia, such as pain and physical damage to the oral tissues, but it would also be an advantage to the clinician to know the effect of pressure changes on certain dental materials in terms of bond strength and microleakage. The following outlines important considerations for cast-crown placement in people who regularly engage in activities associated with barometric stress.

Lyons and coworkers[4] examined whether pressure cycles would cause microleakage in teeth with full cast crowns cemented with zinc phosphate cement, tri-cured glass ionomer cement or a resin cement. They also investigated whether the retention of these crowns would be affected. Sixty single-rooted extracted premolars were divided into 3 groups of 20 teeth according to the cement used. Each group was then subdivided into 2 groups of 10, an experimental group and a control group. Each experimental tooth was then subjected to 15 compression cycles, ranging from 0 to 3 atmospheres, in a pressure chamber. Maximum pressure was attained in 3 minutes and maintained for 3 minutes, and decompression occurred over 3 minutes. Microleakage was detected in all experimental teeth where the crowns were luted with zinc phosphate cement. Seven teeth in the glass ionomer experimental group showed microleakage during pressure cycling, and no microleakage was detected in the resin cement group.

Lyons and coworkers offer several explanations for the microleakage in the glass ionomer and zinc phosphate groups, including volumetric contraction or internal stress within the materials, or porosities caused by mixing that may have expanded and contracted during pressure cycling. They further suggest that microleakage may not have occurred in the resin cement group because the dentinal tubules were obstructed by resin tags, or simply because fracture did not occur because the material was flexible.

The tensile bond strength of the cements was also tested using a universal testing machine (with a speed of 0.5 mm/minute and a 100-kg load).[4] Results indicated that the force required to dislodge the crowns in the experimental group cemented with zinc phosphate was only a tenth that of the controls, and that for glass ionomer was reduced by a half compared with its controls. Pressure cycling did not affect the bond strength of the resin cement group. Based on the results of this study, it is possible that barodontalgia may develop as a result of microleakage following a reduction in lute bond strength during or following pressure cycling. Lyons and coworkers suggest that dentists consider using a resin cement when luting fixed prostheses in patients who will be exposed to significant variations in pressure.

Recommendations

Although barodontalgia is not common, it should not be dismissed as unimportant, as it can pose a serious safety risk to divers, submariners, pilots and airline passengers. The Fédération dentaire internationale (FDI) has classified barodontalgia into 4 groups according to its signs and symptoms; from moderate to severe, they are acute pulpitis, chronic pulpitis, necrosis of the pulp and periapical abscess or a cyst.[8] Each category contains a description of clinical symptom, findings and therapy. FDI also recommends an annual checkup for divers, submariners and pilots, with oral hygiene instructions from dentists familiar with their dental requirements. In addition, patients should not dive or fly in nonpressurized cabins within 24 hours of a dental treatment requiring anesthetic or 7 days following a surgical treatment.[8]

The key feature in avoiding barodontalgia is good oral health. When dealing with patients involved in diving or aviation, clinicians should pay close attention to areas of dentin exposure, caries, fractured cusps, fillings and periapical pathology.[2] If a patient arrives in the office complaining of symptoms of barodontalgia, the examiner should establish whether there is a history of recent flying or diving. Examination should include an estimate of the age of restorations in the suspected area, screening for caries and poor-quality restorations, a percussion test on suspected teeth, an evaluation of the response to electrical stimulation or heat and cold, as well as a radiographic examination.[4] One clinical benefit of barodontalgia is that it may help a dentist locate early caries, leaking restorations and periodontal abnormalities.[5] Also of clinical importance, the placement of a zinc oxide eugenol (ZOE) base was found to prevent barodontalgia when reversible pulpitis was the underlying cause.[1] This is attributed to the well-known sedative affects of ZOE. Another study[3] suggested that when treating people who are subjected to large pressure changes, it is best to avoid procedures such as pulpectomy and capping of an exposed pulp. Rather, endodontic treatment is indicated.

Barodontalgia can pose a serious safety risk to divers, submariners, pilots and airline passengers.

Conclusion

According to the literature, barodontalgia is a rather rare phenomenon. However, Kollmann[3] has suggested that the incidence of barodontalgia may be underestimated. For example, aviators may be reluctant to report pain as they could be refused flying certificates.

It appears that controversy still exists as to the exact etiology of barodontalgia and the mechanisms of the pain. Nevertheless, research has provided useful ways to anticipate, recognize and treat the phenomenon, thereby preventing what could easily turn into a tragedy. Agreement has been reached on 2 factors: the influence of a pressure

gradient and some sort of pathology in oral tissues or sinuses must both be present to result in symptoms of barodontalgia. Certain populations have been specifically identified as having a high risk for barodontalgia. Dentists will be able to provide more efficient diagnosis and care by referring to FDI guidelines, as well as knowing how certain dental materials respond to pressure gradients. Although its occurrence has been known for some time, more research to improve the understanding of barodontalgia would be useful for those providing care. Understandably, many studies are military based because of the potential impact of barodontalgia on the professional activities of pilots and divers. With a significant number of these professionals in the military, there is an optimum environment for carrying out well-controlled research and follow-up. However, a richer understanding of diagnosis and treatment challenges would undoubtedly be gained from research broadened to include recreational divers and civilian aviators. ◆

Roland Robichaud *is a third-year dental student in the faculty of dentistry, Dalhousie University, Halifax, Nova Scotia*

Dr. McNally *is assistant professor, department of dental clinical sciences, faculty of dentistry, Dalhousie University, Halifax, Nova Scotia.*

Correspondence to: *Dr. Mary McNally, Department of Dental Clinical Sciences, Faculty of Dentistry, Dalhousie University, Halifax, NS B3H 3J5. E-mail: mary.mcnally@dal.ca.*

The authors have no declared financial interests.

References

1. Holowatyj R. Barodontalgia among flyers: a review of seven cases. *J Can Dent Assoc* 1996; 62(7):578–84.
2. Kieser J, Holborow D. The prevention and management of oral barotrauma. *N Z Dent J* 1997; 93(414):114–6.
3. Kollmann W. Incidence and possible causes of dental pain during simulated high altitude flights. *J Endod* 1993; 19(3):154–9.
4. Lyons KM, Rodda JC, Hood JA. Barodontalgia: a review, and the influence of simulated diving on microleakage and on the retention of full cast crowns. *Mil Med* 1999; 164(3):221–7.
5. Rauch JW. Barodontalgia — dental pain related to ambient pressure change. *Gen Dent* 1985; 33(4):313–5.
6. Calder IM, Ramsey JD. Odontecrexis — the effects of rapid decompression on restored teeth. *J Dent* 1983; 11(84):318–23.
7. Jagger RG, Jackson SJ, Jagger DC. In at the deep end — an insight into scuba diving and related dental problems for the GDP. *Br Dent J* 1997; 183(10):380–2.
8. Goethe WH, Bater H, Laban C. Barodontalgia and barotrauma in the human teeth: findings in navy divers, frogmen, and submariners of the Federal Republic of Germany. *Mil Med* 1989; 154(10):491–5.