

Incidence and Features of Barodontalgia Among Military Divers

Mathieu Gunepin; Florence Derache; Jean-Eric Blatteau; Idan Nakdimon; Yehuda Zadik

- OBJECTIVE:** Divers are vulnerable to barodontalgia (atmospheric pressure change related dental pain), which may jeopardize diving safety and mission completion. Our aim was to investigate the experience of barodontalgia among western military divers.
- METHODS:** French Armed Forces diving personnel were asked to answer a structured questionnaire including questions regarding their oral health, diving and career features, and barodontalgia while diving. For analysis, the participants were divided into commando/clearance divers (Group A) and ship divers (Group B).
- RESULTS:** All the requested 1389 divers agreed to participate in the study (100%) and 1317 divers (94.8%) who fully completed the questionnaire were included in the analysis. Of these 1317 individuals, 96 (7.3%) suffered from at least 1 episode of barodontalgia while diving, with a total of 119 episodes of barodontalgia. Barodontalgia was more frequent in the upper (62.2%) than the lower dentition (37.8%) (OR = 2.7; 95% CI, 1.6–4.5) and appeared more common during descent (77.3%) than ascent (22.7%) (OR = 11.6; 95% CI, 6.3–31.3). Barodontalgia experience was higher in divers who have an examination less than once per year (14.5%) in comparison to divers who usually have a dental examination once a year or more (6.3%) (OR = 2.5; 95% CI, 1.5–4.2).
- DISCUSSION:** Barodontalgia mostly appeared in the maxilla and during descent; therefore, a great role for barosinusitis in the etiology of oral pain while diving may be suggested. The infrequent experience of barodontalgia in divers who routinely visit the dentist once a year or more suggests that the risk of barodontalgia might decrease with the maintenance of a good oral status.
- KEYWORDS:** diving medicine, military medicine, sport medicine, sport dentistry, dental pain.

Gunepin M, Derache F, Blatteau J-E, Nakdimon I, Zadik Y. Incidence and features of barodontalgia among military divers. *Aerosp Med Hum Perform*. 2016; 87(2):137–140.

Barodontalgia (also called tooth squeeze), dental pain related to changes in atmospheric pressure, has been described among self-contained underwater breathing apparatus (scuba) divers since the mid-20th century.^{12,14} Similar pain may affect aircrews and air passengers.¹¹ This phenomenon has the potential to cause suffering, early cessation of diving, and even to jeopardize the safety of the diver.⁴

Most cases of in-flight barodontalgia reflect acute exacerbation of existing subclinical diseases and the rest of the cases are pain related to barotraumas (of dental or facial cavities) which arise during barometric changes. The reported sources of in-flight barodontalgia included dental caries and faulty dental restorations without pulp involvement (29%), necrotic pulp with or without peri-apical inflammation (28%), vital pulp pathology (14%), and recent dental treatment (11%). One-tenth of the cases of pain in the oral cavity are caused by barosinusitis.¹³ Currently, there is no consensus regarding the pathophysiological mechanism of barodontalgia.

Data regarding the etiology of barodontalgia while diving is not available. A total of 9% and 22% of American and Australian civilian divers, respectively, have experienced one or more episodes of barodontalgia.^{5,9} In these populations, this pain phenomenon was most prevalent in the third decade of life with no gender preference. There are only a limited number of studies regarding barodontalgia in general and especially among (military) divers that have been published in the literature during the past two decades. The aim of this research was to study the features of barodontalgia among the French military divers

From the Subaquatic and Hyperbaric Operational Research Team of the Military Institute of Biomedical Research, Toulon, France.

This manuscript was received for review in July 2015. It was accepted for publication in October 2015.

Address correspondence to: Dr. M. Gunepin, Subaquatic and Hyperbaric Operational Research Team of the Military Institute of Biomedical Research, BP 600, 83800 Toulon Cedex 9, France; mgunepin@yahoo.fr.

Reprint & Copyright © by the Aerospace Medical Association, Alexandria, VA.

DOI: 10.3357/AMHP.4424.2016

belonging to the navy, air force, army, and Gendarmerie Nationale; our hypotheses were that barodontalgia was less common among military divers in comparison to the previous reports regarding civilian divers, and that barodontalgia experience is associated with lower frequency of routine dental examination.

METHODS

The Institutional Review Board of the Medical Corps approved the study design; informed consent was obtained from each participant prior to enrolment in the study. The study population was described earlier in a study on dental barotrauma in French military divers.² Briefly, diving personnel in the French Armed Forces (navy, air force, army, and Gendarmerie Nationale) who attended an obligatory periodic medical examination between March 2011 to July 2014 at the Center for Hyperbaric Medicine and Diving Expertise (SMHEP) of the Sainte Anne's Military Hospital (Toulon, France) were asked by the nurse to answer a structured questionnaire. This institute is the only military diving medical center of the French Armed Forces. Divers in their training period were not included in the study. The participation in the study was voluntary.

Types of diving included commando divers (combat divers for offensive military missions), clearance divers (for mine-warfare missions and underwater works such as welding, cutting, and assembly of metallic structures, and clearing of port access), and ship divers (divers for surveying and routine maintenance of the watercraft hull, and basic underwater work such as security and safety operations on the forward underwater area of ships). The simple questionnaire included three sections: demographics and career features, general dental questions, and barodontalgia episode features (**Fig. 1**).

Statistical Analysis

Data was tabulated in MS-Excel software and a descriptive analysis was performed. For analysis, the participants were divided into two groups according to their type of diving, namely commando/clearance divers (Group A) and ship divers (Group B). For comparison between the groups, data was analyzed (Wald χ^2 analysis) using SPSS for MS-Windows version 22. *P*-values < 0.05 were considered statistically significant.

1. Personal characteristics: Age, gender, type of diving, length of service.
2. What is the frequency of your dental visits?
3. Have you ever experienced dental pain while diving? If, yes,
 - a. How many pain episodes have you experienced?
 - b. When did the pain appear?
 - c. What was the pain location in the dentition?

Fig. 1. The structured questionnaire.

RESULTS

All the requested 1389 divers agreed to participate in the study and answered the questionnaire (100%). However, 72 questionnaires (5.2%) were incomplete and, therefore, were not included in the analysis. Overall, 1317 (94.8%) questionnaires were fully completed and included in the analysis, reflecting 60.6% of all French military divers. Of the participants, 98.8% were men. The military profession and demographics are presented in **Table I**.

Features of episodes of barodontalgia while diving are presented in **Table II**. While diving, 96 divers (7.3%) suffered from at least 1 episode of barodontalgia and 119 cases of barodontalgia were reported (up to 2 episodes per diver). In the study, barodontalgia was more frequent in the maxilla (62.2%) than the mandible (37.8%; OR = 2.7; 95% CI, 1.6–4.5; *P* < 0.001) and appeared more frequently during descent (77.3%) than ascent (22.7%; OR = 11.61; 95% CI, 6.3–31.3; *P* < 0.001).

Barodontalgia was more common among group B divers in comparison to group A divers (10.3% vs. 6.2%, respectively; OR = 1.74; 95% CI, 1.1–2.8; *P* = 0.016; **Table III**) and more among divers who had a routine dental examination frequency of ≥ 1 yr, i.e., less than one dental examination every year (respectively, 14.5% and 6.3%; OR = 2.5; 95% CI, 1.5–4.2; *P*, 0.001; **Table III**).

DISCUSSION

According to the present results, the number of cases of barodontalgia is higher in divers of Group B (ship divers) than Group A (combat and clearance divers). This difference could be attributed to the specificities of these two categories of divers: subjects of Group B dive only occasionally, i.e., they have non-diving positions, but may be asked for underwater work, diving from time to time (once a week, approximately 50 times per year) because of their qualification in military diving. Therefore, their medical follow-up is conducted by physicians who are qualified in diving medicine, but are not experts. For subjects of Group A, diving is their main occupation, they are treated by experts in diving medicine, and maintaining a healthy lifestyle (including oral health) is essential to their diving fitness and their military career. Indeed, more Group A divers have routine dental examinations at least once a year (96.5%) in comparison to Group B divers (84.9%; *P* < 0.0001; **Table III**).

According to previous reports, although the diving environment (elevation of 1 atm in atmospheric pressure for every 10 m of depth) is considered to exert more barometric exposure on the human body in comparison to the flight environment (pressure range of 1 to 0 atm between ground level to outer space), experience of barodontalgia is considered to be similar between aircrew and divers.¹³ In the present study a considerably small group of individuals, 7.3%, suffered from barodontalgia while diving in comparison to aircrew in general (11.0%) and to military aircrew (9.6%);¹⁴ however, the present result (7.3%) is quite similar to the experience rate recently reported among French civilian (6.5%) and military (6.8%) aircrew.⁷

Table I. Demographics of Participants According to Type of Diving.

DIVING CATEGORY	NUMBER OF DIVERS (% OF PARTICIPANTS)	LENGTH OF SERVICE, YEARS \pm SD	MALE:FEMALE RATIO	LIMIT OF DIVING DEPTH (m)
Group A				
Commando divers	66 (5.0%)	10.2 \pm 7.5	66:0	<7 m oxygen, <60 m Air
Clearance divers	338 (25.7%)	10.5 \pm 7.5	335:3	<60 m Air, <80 m Trimix
Total	404 (30.7%)	10.5 \pm 7.5	401:3	N/A
Group B				
Ship divers	913 (69.3%)	9.9 \pm 6.7	900:13	<35 m Air
Total	1317 (100%)	10.2 \pm 7	1301:16	N/A

N/A, not applicable.

The present results may strengthen the understanding that, besides pressure changes, there are other factors influencing the evoking of pain. In the mid-1940s, Ritchey and Orban suggested that rapid ascent is related to a higher rate of barodontalgia;⁸ rapid ascent may intensify the barometric effect because the more rapid the ascent, the less ability there is to physiologically compensate for barometric changes. More recently, Laval-Meunier *et al.* offered that factors such as speed, acceleration, temperature, and vibration may contribute to the induction of pain during flight.⁷ A hypoxic environment is unlikely in modern flight and during diving because of the current breathing devices. However, local dental ischemia was offered in the 1940s as an explanation for barodontalgia in teeth affected by pulpitis.^{3,6}

According to the present results, barodontalgia while diving is less prevalent among military divers (7.3%) than civilian divers (11.2%).^{5,9} This finding may be attributed to better oral health among the military divers as 88.5% of the participants have dental examination at least once a year. Among the military divers who participated in the present study, the experience of barodontalgia was lower among those who had ≥ 1 dental examination per year (Table II).

We found that barodontalgia was more frequent in the upper dentition than the lower dentition. These results are consistent with previous studies in civilian populations⁵ and may reflect the significant role of (maxillary) sinus barotrauma in cases of barodontalgia while diving. Furthermore, the finding that barodontalgia appeared more frequently during descent than ascent may also indicate a significant role of barosinusitis. However, we did not study the pathologies involved in the barodontalgia

cases in this research; thus, this assumption should be examined with caution.

The strength of this study is the number of participants (the studied population is one of the largest populations studied for barodontalgia rate during the last 2 decades), the high response rate of the subjects queried, and the fact that information relating to the differing patterns of diving exposure was included. Moreover, this study presents, for the first time, data of barodontalgia while diving among western military divers.

Weaknesses of this study include the fact that the data is retrospective and self-reported with no clinical examination and, therefore, may be subjected to under-reporting (because the individuals' interest to avoid further medical/dental examination, treatment, and diving restrictions) or over-reporting (because dental pain while diving may not be related to barometric changes but to the mouthpiece¹ or not related to diving at all). However, a self-reporting questionnaire is the preferred method of the vast majority of barodontalgia research in the last two decades (with the exception of a few studies only¹⁰). Therefore, because we used a similar method to the methods that have been used in previous studies (among civilian diver and military and civilian aircrew), a comparison between findings can be made. Because they could influence the frequency of barodontalgia during diving, the fact that the frequency and the total number of dives of each diver were not collected may be another weakness of this study.

This first study of barodontalgia experience among western military divers found a relatively low experience rate (7.3%). The appearance of most of the barodontalgia in the upper dentition and during descent leads to the assumption of the role of

Table II. Features of Episodes of Barodontalgia While Diving.

PARAMETER STUDIED	NUMBER OF CASES BARODONTALGIA	% OF BARODONTALGIA	P-VALUE, OR [95% CI]*
Pain location [†]			
Upper dentition	79	62.2% (79/127)	$P < 0.001$, 2.7 [1.6–4.5]
Lower dentition	48	37.8% (48/127)	
Pain appearance ($N = 119$)			
Descent	92	77.3% (92/119)	$P < 0.001$, 3.4 [6.3–31.3]
Ascent	27	22.7% (27/119)	
Barodontalgia experience according to frequency of dental visits			
≥ 1 dental examination / year	74	6.3% (74/1165)	$P < 0.001$, 2.5 [1.5–4.2]
<1 dental examination / year	22	14.5% (22/152)	

* Wald Chi-Squared Test.

[†] The sum is 127 because 8 divers had pain in both jaws in the same episode.

Table III. Frequency of Routine Dental Visits and Barodontalgia in Divers by Group.

GROUP	N	≥1 ROUTINE DENTAL EXAMINATION/YEAR		BARODONTALGIA	
		NUMBER OF PARTICIPANTS (%)	P-VALUE, OR [95% CI]*	NUMBER OF CASES (%)	P VALUE, OR [95% CI] ^A
Group A [†]	404	390 (96.5%, 390/404)	<i>P</i> < 0.0001, 5.0 [2.8–8.7]	25 (6.2%, 25/404)	<i>P</i> = 0.016, 0.6 [0.4–0.9]
Group B [‡]	913	775 (84.9%, 775/913)		94 (10.3%, 94/913)	
Total	1317	1165 (88.5%, 1165/1317)		119 (9.0%, 119/1317)	

* Wald Chi-Square Test.

[†] Commando and clearance divers.[‡] Ship divers.

barosinusitis in the etiology of oral pain while diving. The lower frequency of barodontalgia in the divers who had frequent dental examinations (at least once a year) suggest that barodontalgia mostly reflects acute exacerbation of existing subclinical diseases and may be (partly) prevented by proper dental surveillance. A prospective study with matched groups comparing outcome with varying frequency of dental intervention is needed to prove that assertion.

ACKNOWLEDGMENTS

Authors and affiliations: Mathieu Gunepin, DDS, Subaquatic and Hyperbaric Operational Research Team of the Military Institute of Biomedical Research, French Military Health Service, Toulon, France; Florence Derache, DDS, Military Medical Center of Draguignan, French Military Health Service, Draguignan, France; Jean-Eric Blatteau, M.D., Ph.D., Center for Hyperbaric Medicine and Diving Expertise, Toulon, France; and Yehuda Zadik, DMD, MHA, Israeli Air Force Surgeon General Headquarters and Medical Corps, Israel Defense Forces, Tel Hashomer, Israel.

REFERENCES

- Gunepin M, Zadik Y, Derache F, Dychter L. Non-barotraumatic tooth fracture during scuba diving. *Aviat Space Environ Med.* 2013; 84(6): 630–632.
- Gunepin M, Derache F, Dychter L, Blatteau JE, Nakdimon I, Zadik Y. Dental barotrauma in French military divers: results of the POP Study. *Aerosp Med Hum Perform.* 2015; 86(7):652–655.
- Harvey W. Dental pain while flying or during decompression tests. *Br Dent J.* 1947; 82(6):113–118.
- 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):380–382.
- Jagger RG, Shah CA, Weerapperuma ID, Jagger DC. The prevalence of orofacial pain and tooth fracture (odontocrexia) associated with SCUBA diving. *Prim Dent Care.* 2009; 16(2):75–78.
- Kennebeck GR, Knudtson KF, Goldhush AA, Kennon RH, Wald AH, et al. Symposium on problems of aviation dentistry. *J Am Dent Assoc.* 1946; 33:827–844.
- Laval-Meunier F, Bertran PE, Arrive E, Paris JF, Monteil M, et al. Frequency of barodontalgia among military or civilian pilots and aircrew members. *Aviat Space Environ Med.* 2013; 84(10):1055–1060.
- Ritchey B, Orban B. Toothache at altitude. *J Endod.* 1946; 1(2):13–18.
- Taylor DM, O'Toole KS, Ryan CM. Experienced scuba divers in Australia and the United States suffer considerable injury and morbidity. *Wilderness Environ Med.* 2003; 14(2):83–88.
- Zadik Y, Chapnick L, Goldstein L. In-flight barodontalgia: analysis of 29 cases in military aircrew. *Aviat Space Environ Med.* 2007; 78(6):593–596.
- Zadik Y. Aviation dentistry: current concepts and practice. *Br Dent J.* 2009; 206(1):11–16.
- Zadik Y. Barodontalgia. *J Endod.* 2009; 35(4):481–485.
- Zadik Y. Barodontalgia: what have we learned in the past decade? *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010; 109(4):e65–e69.
- Zadik Y, Drucker S. Diving dentistry: a review of the dental implications of scuba diving. *Aust Dent J.* 2011; 56(3):265–271.