Odontology
https://doi.org/10.1007/s10266-022-00714-8

ORIGINAL ARTICLE

Orofacial problems in scuba diving: prevalence and prevention—a large-scale survey among civilian divers in France

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Received: 31 May 2021 / Accepted: 22 March 2022

Abstract

Self-contained underwater breathing apparatus (SCUBA) diving is becoming widely democratized among hobbyist practitioners. It can cause orofacial problems, mostly linked to pressure changes. The aim of this study was to assess the prevalence of these problems and to analyze civilian divers' behavior about their dental prevention in France, via a cross-sectional study. Data from 1015 French civilian divers were collected via a nationwide online questionnaire in which participants indicated information concerning orofacial experienced problems during their diving activity, and their medical preventive habits. As results, oral manifestations were experienced by 25.2% of the divers, including barodontalgia (10.8%), mouth syndrome (13.4%), gum pain (2.8%) and dental fractures caused by barotrauma (3.7%) or shocks (1.9%). Mouth syndrome was more frequent among women (18.6%) and divers aged between 18 and 34 years (18.9%). The prevalence of dental fractures increased significantly with age. High diving level was associated with more frequent barodontalgia (17.5%), gum pain (7%) and barotrauma (7.6%). Among respondents, 43.5% completed a dental examination before a diving season and showed fewer oral problems during their scuba diving practice than those who did not. In conclusion, oral problems in scuba diving represent frequent events that can compromise the safety of divers. Despite awareness rising, there is a lack of recourse to the dentist. This leads to incomplete information, especially concerning the preventive means available to divers.

Keywords Dental barotrauma · Barodontalgia · Mouth syndrome · Hyperbaric medicine · Epidemiology · Tooth

Introduction

Self-contained underwater breathing apparatus (SCUBA) diving has known an important increase of popularity since the middle of the twentieth century thanks to innovations in its equipment. In France, this enthusiasm was characterized by 350,000 practitioners in 2010 and has continued to grow ever since [1]. Most of them are trained by the FFESSM program (Fédération Française d'Etudes et de Sports Sous-Marins/French Federation of Underwater Studies and Sports) which corresponds to the French diving certification with four graduations, the fourth representing the most experienced divers.

Scuba diving presents many risks to the health of divers and thus requires a medical certificate from a general practitioner to prevent accidents related to this activity. More specifically, orofacial accidents have been described in the literature and experienced by divers, such as dental barotrauma, barodontalgia, or the diver's mouth syndrome, leading to pain, discomfort and even more serious risks of diving accidents. Indeed, pressure changes during the immersion do influence fluid physics. These changes, as well as the iatrogenic effects of the oral mouthpiece, can instigate orofacial problems for which prevention exists.

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Published online: 30 May 2022

Dental barotrauma

According to the Boyle's law, the volume of a gas at constant temperature varies inversely with the surrounding pressure. Into the orofacial region, this phenomenon especially affects rigid cavities such as the ear, facial sinuses and teeth [2]. The variation of pressure into these cavities requires some means of communication with the outside environment to allow the evacuation of the air. If these ducts are clogged or too narrow, sudden changes in pressure can lead to a barotrauma [3].

Dental barotrauma is defined as a tooth or restauration fracture and reduced retention of dental fixed prosthetics restorations such as ceramic crowns or bridges [4]. This phenomenon appears during the descent phase by a crushing of the dental structures while the expansion of an air bubble trapped during the ascent phase will give rise to an explosion [5, 6]. Therein, odontocrexis corresponds to a tooth fracture due to the growing of an air bubble caused by the presence of a tooth decay, a lack of sealing or a porosity in a restoration material [7].

In their in vitro experience, Calder and Ramsey showed that odontocrexis occurred exclusively on decayed or defective teeth [8]. To date, only one study reports a case of dental barotrauma on an healthy tooth [9]. According to epidemiological data, the prevalence of tooth fractures caused by barotrauma is approximately 1% [10]. Nonetheless, the consequences of a dental barotrauma can be dramatic if fragments are inhaled during the diving session, insofar as this may compromise the safety of the diver [3, 11].To avoid these accidents, prevention of dental barotrauma consists in regular visits to the dentist to identify tooth decay and defective restorations [3, 12].

Barodontalgia

Primary described during World War II in flight conditions, barodontalgia is considered as direct or indirect dental pain consecutive to barometric changes [13]. Etiologies are still unknown, but studies favor the prior existence of a pulp or a periapical pathology. Hyperemia and fluid movements into dentin tubules are the main hypothesis to explain barodontalgia [13–15]. Therein, it is possible to prevent the occurrence of barodontalgia with the upkeep of a good oral health, a rigorous oral hygiene and the treatment of dental infections [16]. It is, however, admitted that this pain can be indirectly caused by an irradiation due to an ear or a sinus barotrauma [13].

Diver's mouth syndrome

Mouthpiece is an accessory for the diver to grip the air delivery system. Its design allows obtaining a seal around the lips and an occlusion support (Fig. 1), though the use of a standard mouthpiece can lead to temporomandibular disorders and teeth deterioration [3, 17]. Indeed, mouthpiece design generates a non-physiologic protrusive position of the mandible and the following isometric contraction of the associated muscles can induce symptoms of temporomandibular dysfunctions (TMD) [18, 19]. This phenomenon particularly affects divers with an history of TMD but it can also appear among initially healthy people [3, 20].

According to the literature, the prevalence of mouth syndrome is estimated between 24 and 68% [3], and symptoms increase among women and beginners in diving [21, 22]. The benefits of anatomic personal mouthpieces have been demonstrated by a reduction of myocontraction and a better physiologic mandibular position [23, 24]. Thus, anatomic personal mouthpieces contribute to a better comfort and a significant reduction of TMD symptoms compared to standard mouthpieces [25].

Although there are more and more hobbyist divers, there are no existent data in the literature concerning the prevalence of these orofacial problems linked to scuba diving for French civil divers, and their behavior regarding the prevention of these particular problems. Therefore, our objectives in this study were to determine the prevalence of these problems in this population and to analyze the behavior of these divers about their prevention.

Materials and methods

Population

This study reports on an online survey by questionnaire, conducted among French civilian divers, on information about their orofacial-related experiences during their scuba diving activities, their knowledge and medical observance towards oral prevention measures in the field of scuba diving. Divers included were over 18 years old, of French nationality, and with a scuba diving graduation level.

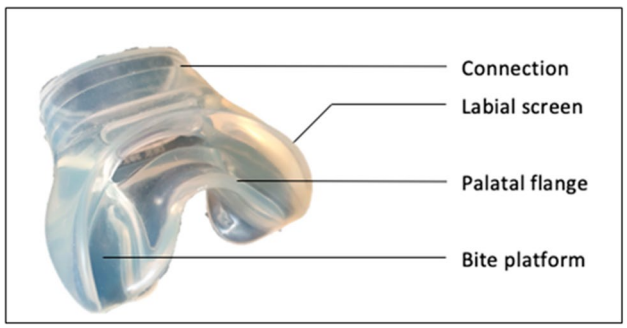

Fig. 1 Commercial standard mouthpiece

Questionnaire and public involvement

Information was collected retrospectively via a voluntary online nationwide questionnaire deployed on Google® form (Google, Mountain View, CA), and concerned:

1. General data to define gender, age and diving experience.
2. Orofacial experienced problems, especially orofacial pain and dental fractures caused by a barotrauma or a shock.
3. Knowledge and habits in oral prevention linked to scuba diving.

Information regarding age, gender and diving experience were recorded as categorical. Outcomes regarding orofacial experienced problems were recorded as binary and analyzed as such. A preliminary feasibility study was conducted with twenty divers in January 2020 and led to minor corrections. Once the questionnaire was easily understandable and unambiguous, it was spread to French diver's community from February 3rd 2020 to July 15th 2020.

Diving centers were contacted throughout France, and each volunteer club manager shared the questionnaire by e-mails to the members of the center. Participants were also recruited through shared social network posts on the private FFESSM Facebook® page containing a link to the questionnaire. They were informed at the beginning of the questionnaire of the purpose of the study, and that their participation would be voluntary and anonymous.

Ethics

This study was submitted to the Ethical Committee of the University Hospitals of Strasbourg, France, and received the authorization nCE-2020-145.

Data analysis

We described the prevalence of various diving accidents, as well as frequencies of other variables. We performed bivariate analysis using odds ratio, Pearson's Chi-squared test or Exact Fischer's test to assess significant differences between proportions. A threshold at $p \leq 0.05$ was set to determine significant differences. Finally, logistic regression was used to assess the impact of age and gender on the studied frequencies.

Statistical software

Data analysis was conducting using Stata v.13 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP), Microsoft Excel© software and BiostaTGV (INSERM, Paris, France, on http://biostatgv.sentiweb.fr).

Results

General data and diving experience

In total, 1015 civilian divers participated from all regions in France: 601 men (59.2%) and 414 women (40.8%). Ages were equally represented except the "65 years and more" category which represented only 5.5% of the sample with 56 people (Table 1). Participants were mostly trained by the FFESSM certification (96.4%) and had globally a confirmed diving experience since 61.7% of them presented at least the third diving graduation. Women and young people represented a broad proportion of low-level divers (Table 1). A large majority of participants (896 participants, 88.3%) were registered in a diving association at the time of the study.

Orofacial experienced problems

Collected data revealed that 812 participants lived at least one painful experience in the orofacial region during a dive (80% of the sample). Among them, 230 (28.3%) had to interrupt their current dive as a result of this pain. Prevalence was particularly higher in the ears (66.5%) and sinus regions (43.8%) (Table 2).

Regarding specifically oral problems during a dive, 256 respondents (25.2%) indicated having experienced this kind of event. This result combines barodontalgia (10.8%), mouth syndrome (13.4%), gum pain (2.8%) and dental fracture caused by a shock (1.9%) or a barotrauma (3.7%) (Table 3). Statistical analysis showed a significant association between gender and oral problems. Indeed, women seemed to be more exposed to jaw pain (mouth syndrome) during a dive (18.6%, OR 2.1, $p \leq 0.001$), but experienced fewer dental barotraumas (1.9%, OR 0.4, $p \leq 0.05$) compared to men (Table 3).

Prevalence of mouth syndrome and dental fractures showed a significant difference according to the age of divers. Indeed, young divers aged between 18 and 34 years seemed to be more affected by mouth syndrome (18.9%) compared to older participants (Table 3). On the contrary, barotrauma and dental fractures caused by shocks were found more and more as divers got older, in particular among the "65 + " category (Table 3).

Finally, participants with the 4th diving level graduation reported more barodontalgia (17.5%), gum pain (7%) and dental barotrauma (7.6%) than participants of lowers levels (Table 3).

The exploration of the inter-relations among the conditions showed positive associations for all of them. Significant

Table 1 Characteristics of participant divers ($N=1015$)

	Gender		Diving graduation (level)					Total
	Men	Women	Lev. 1	Lev. 2	Lev. 3	Lev. 4	Instructor	
	% of total men	% of total women	% of the total of each level					
Age								
18–34	102 (17%)	126 (30%)	59 (41%)	80 (34%)	40 (15%)	23 (13%)	26 (13%)	228
35–49	198 (33%)	148 (36%)	52 (37%)	92 (37%)	80 (30%)	69 (40%)	53 (29%)	346
50–64	259 (43%)	126 (30%)	33 (21%)	63 (26%)	119 (45%)	70 (42%)	100 (52%)	385
65 +	42 (7%)	14 (3%)	1 (1%)	8 (3%)	25 (9%)	10 (6%)	12 (7%)	56
Diving graduation (level)								
Lev. 1	67 (10%)	78 (20%)						145
Lev. 2	115 (20%)	128 (30%)						243
Lev. 3	165 (27%)	99 (24%)						264
Lev. 4	115 (19%)	57 (14%)						172
Instructor	139 (24%)	52 (12%)						191
Total	601	414	145	243	264	172	191	

Table 2 Prevalence of at least one orofacial pain experience during a dive according to its location

Pain experience location	Number of divers who noticed the event (n)	Prevalence ($N=1015$) (%)
Sinus	445	43.8
Ears	675	66.5
Teeth (barodontalgia, barotrauma and shock)	132	13
Gum	28	2.8
Jaw (mouth syndrome)	136	13.4
Others	3	0.3
Never experienced pain during a dive	203	20

($p<0.001$) associations were: barodontalgia with all the studied impacts, except mouth syndrome; mouth syndrome with gum pain; GUM pain with barodontalgia, and mouth syndrome; dental shocks with barotrauma and barodontalgia; barotraumas with dental shocks and barodontalgia.

A significant association was identified between age and gender with more women in the lower age group; between age and level with more young divers in low levels of practice; between gender and level with more women in low levels of practice. However, the age-gender association is the only one that gave rise to an interaction concerning the studied conditions in logistic regression (Table 4).

Knowledge and habits in medical prevention

A total of 960 of all 1015 participants (94.6%) were aware of oral health risks specifically related to scuba diving. Among these informed divers ($N=960$), advice and information were mainly obtained during the diving formation (90%) and then by discussions between divers (19.1%), by media such as books/magazines/documentaries/posters (15.6%), by dentists (11.6%) and by general physicians (7.5%) (Fig. 2). Among the informed divers, 711 (74.1%) felt sufficiently informed about these risks.

In terms of dental preventive habits, 442 of the whole sample (43.5%) completed a dental examination before a diving season (Fig. 3). Divers who attended a dental appointment for examination or prevention before a diving season reported globally fewer oral-related problems compared to those who did not; however, these differences are not significant (Table 3).

A significant association was identified between age and prevention with younger divers using prevention less (29% for the 18–34 years, versus 43, 53 and 43%, respectively, for 35–49, 50–64 and 65 + years); between level and prevention with more use of prevention for higher level divers (53% for monitors, versus 29, 38, 48 and 46%, respectively, for divers of levels 1, 2, 3 and 4).

In total, 357 divers of the whole sample (35.2%) had not been informed by their dentist that specific dental care was

Table 3 Prevalence of oral-related impacts according to location and significant descriptive factors

	Barodontalgia	OR	*p*	Gum pain	OR	*p*	Mouth syndrome	OR	*p*	Dental barotrauma	OR	*P*	Dental shock	OR	*p*
Full population (*N* = 1015)	110 (10.8%)			28 (2.8%)			136 (13.4%)			38 (3.7%)			19 (1.9%)		
Descriptive variable															
Gender															
Men (*n* = 601)	67 (11.1%)			15 (2.5%)			59 (9.8%)			30 (5%)			14 (2.3%)		
Women (*n* = 414)	43 (10.4%)	0.9	NS	13 (3.1%)	1.3	NS	77 (18.6%)	2.1	***	8 (1.9%)	0.4	*	5 (1.2%)	0.5	NS
Age															
18–34 (*n* = 228)	22 (9.7%)			7 (3.1%)			43 (18.9%)			2 (0.9%)			1 (0.4%)		
35–49 (*n* = 346)	45 (13%)	1.4	NS	8 (2.3%)	0.7	NS	53 (15.3%)	0.8	NS	14 (4.1%)	4.8	*	4 (1.2%)	2.7	NS
50–64 (*n* = 385)	39 (10.1%)	1	NS	13 (3.4%)	1.1	NS	36 (9.4%)	0.4	***	18 (4.7%)	5.5	*	10 (2.6%)	6.1	NS
65 + (*n* = 56)	4 (7.1%)	0.7	NS	0 (0%)	–	NS	4 (7.1%)	0.3	***	4 (7.1%)	8.7	*	4 (7.1%)	17.5	**
Diving graduation															
1 (*n* = 145)	9 (6.2%)			0 (0%)			21 (14.5%)			0 (0%)			1 (0.7%)		NS
2 (*n* = 243)	17 (7%)	1.1	NS	3 (1.2%)			36 (14.8%)	1	NS	7 (2.9%)			1 (0.4%)	0.6	NS
3 (*n* = 264)	30 (11.4%)	1.9	NS	5 (1.9%)	1.5	NS	27 (10.2%)	0.7	NS	7 (2.7%)	0.9	NS	6 (2.3%)	3.4	NS
4 (*n* = 172)	30 (17.5%)	3.2	**	12 (7%)	6	**	26 (15.2%)	1	NS	13 (7.6%)	2.8	*	4 (2.3%)	3.4	NS
Instructor (*n* = 191)	24 (12.6%)	2.2	NS	8 (4.2%)	3.5	NS	26 (13.6%)	0.9	NS	11 (5.8%)	2.1	NS	7 (3.7%)	5.5	NS
Dental prevention															
Yes (*n* = 442)	50 (11.3%)			11 (2.5%)			58 (13.1%)			22 (5.0%)			6 (1.4%)		
No (*n* = 573)	60 (10.5%)	0.9	NS	17 (3%)	1.2	NS	78 (13.6%)	1	NS	16 (2.8%)	1.8	NS	13 (2.3%)	1.7	NS

p NS > 0.05; * ≤ 0.05; ** ≤ 0.01; *** ≤ 0.001

NS non-significant

Table 4 Odd-ratios of oral-related impacts according to the interaction between age and gender

	Barodontalgia		Gum pain		Mouth syndrome		Dental barotrauma		Dental shock	
	OR	*p*	OR	*P*	OR	*p*	OR	*p*	OR	*p*
Women 18–34	Reference									
Men 18–34	0.4	*	0.1	*	0.8	NS	1	NS	1.2	NS
Men 35–49	0.9	NS	0.2	*	0.5	*	4.2	NS	1.7	NS
Men 50–65	0.5	NS	0.3	*	0.3	***	4.4	NS	5.5	NS
Men 65 +	0.3	NS	–	–	0.1	*	8.1	NS	–	–
Women 35–49	0.6	NS	0.2	NS	1	NS	2.4	NS	0.6	NS
Women 50–65	0.5	NS	0.4	NS	0.6	NS	1.9	NS	1.9	NS
Women 65 +	0.3	NS	–	–	1	NS	–	–	5.1	NS

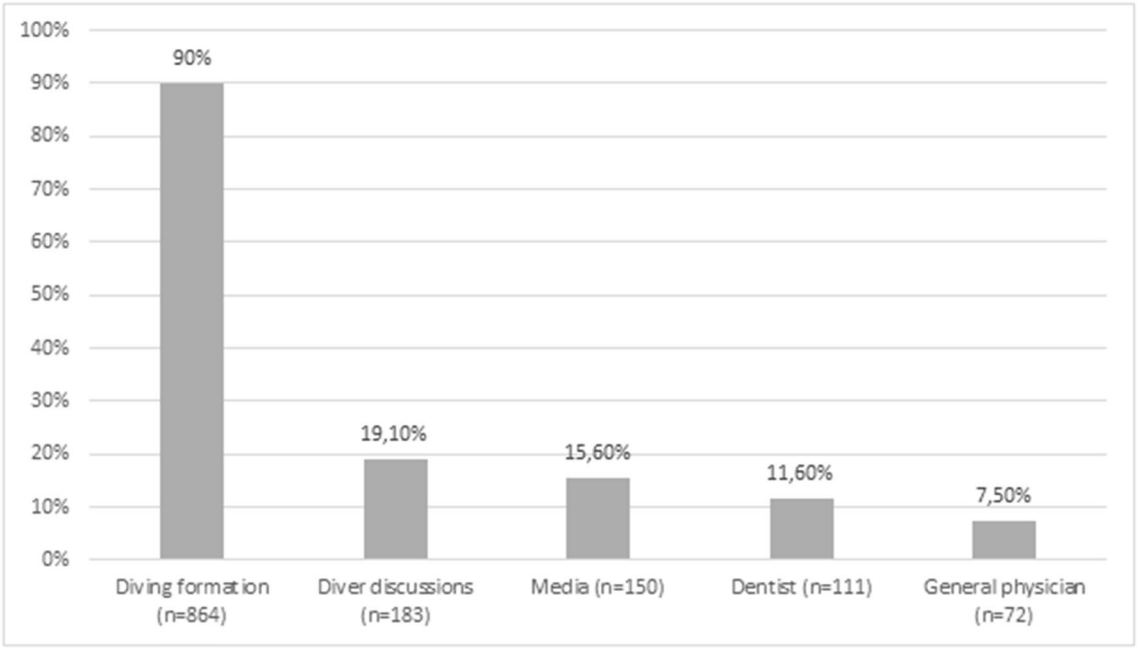

Fig. 2 Distribution of awareness—raising information origins about oral risks in diving ($N = 960$)

required to practice scuba diving. Only 36 divers (3.6%) used an anatomic personal mouthpiece and only 131 (12.9%) were informed of their existence.

Discussion

Population and methodology

The study dealt with a population for which few data are available in the literature, while orofacial pain in diving is frequent and can be serious. In France in 2015, Gunepin et al. led a survey among divers but it was limited to professional military divers [26]. We managed to involve a large number of civilian participants who showed a great interest for the topic. Thus, the results make it possible to reach high statistical significance levels compared to similar studies worldwide.

As with any study collecting responses through social media, potential for bias in the current study may derive from the possibility of one respondent logging the response several times. However, it is unlikely that this happened, and that this source of error could have greatly impacted the results of the study due to the large size of the sample and the detailed instructions that were given before completing the questionnaire.

The pain experiences referred to in the questionnaire may have happened a long time ago for the divers, leading to a potential memory bias. To correct this bias, our questionnaire was deliberately short to focus only on points of interest.

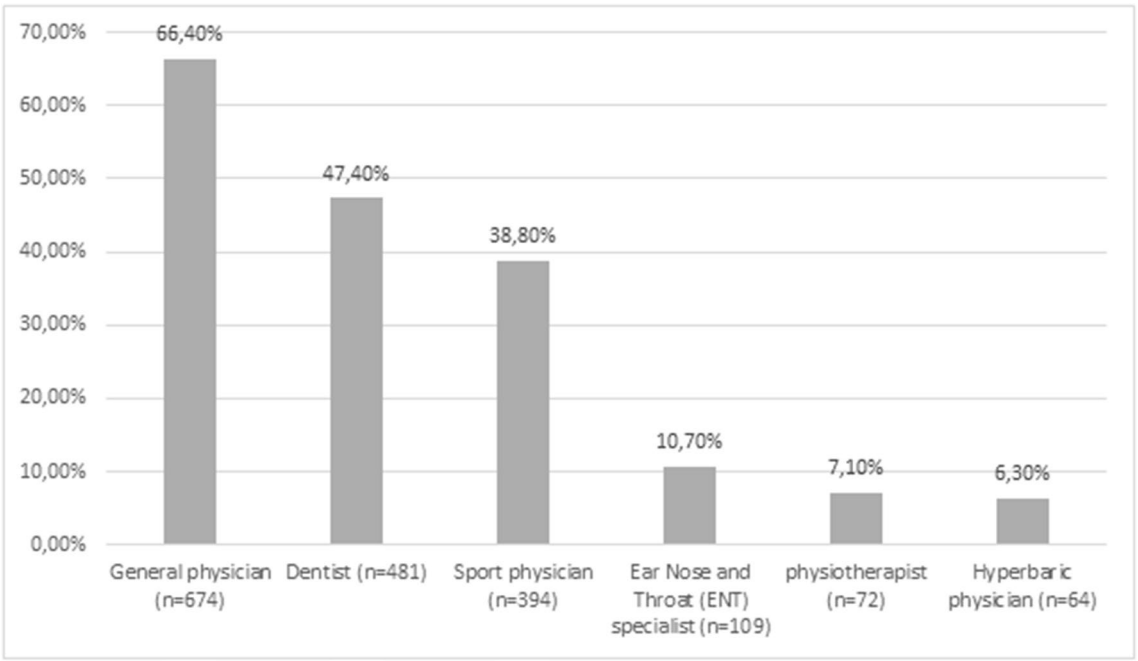

Fig. 3 Distribution of divers' visits to health professionals before a diving season ($N=1015$)

The studied population was composed by experienced divers. This is probably due to the method of recruitment in diving centers and associations. We noticed that people over 65 years old were less represented in the sample (Table 1). This disparity can be explained by the diffusion method of the study, for which access required skills about digital tools. Yet, knowing that divers over 60 years old were 1.7% of the population of divers in France in 2000 [27], and that this part of the population was expected to increase over time, our sample tends to be representative.

Prevalence of orofacial problems in scuba diving

In our study sample ($N=1015$), the prevalence of oral problems was 25.2% ($N=256$). In comparison, the study led by Gunepin et al. indicated a prevalence of 12.5% among military divers for these same events [26]. The latter reported a rigorous monitoring of military practitioners, which can explain this difference compared to our results.

When focusing on specific manifestations, their prevalence is consistent with those from other studies (Table 5) [10, 26, 28–31]. However, we reported a higher prevalence of dental barotrauma (3.7%) than Zadik's review of the literature in 2009 who mentioned a prevalence around 1% [4].

It is interesting to notice that given the positive associations for all the outcomes we have studied, a diver would be more likely to present one kind of orofacial problem if he/she is already presenting another, showing that some divers may present a general unfavorable condition. It may also be possible that some divers have a better memory of all past problems.

In our study, women and young divers reported a significant higher prevalence of mouth syndrome. That corresponds to the risk factors of TMD in the global population, according to Bueno et al. in 2018 [32]. This observation assumes that patients at risk of developing TMD symptoms would be predisposed to be affected by mouth syndrome during a dive. To illustrate this idea, Aldridge's study showed a higher prevalence of mouth syndrome (26%) than in others studies, which can be explained by the inclusion of younger divers, namely aged between 11 and 40 [31].

Dental fractures and barotrauma occurred particularly in older participants. The preferred hypothesis based on a link between the presence of more restorations and the prevalence of barotrauma would be interesting to investigate. Indeed, the increase of the number of dental reconstructions with age could explain this significant difference in divers over the age of 65, because reconstructions make teeth more fragile towards pressure variations. Consequently, this group of age should be even more attentive to preventive dental visits to verify their teeth and the integrity of their restorations. Since we asked if divers ever experienced those conditions, it is also logical to see an increase among older divers who had more opportunities to experience them.

Finally, divers with a high level of practice seemed to be more affected by barodontalgia, dental barotrauma and gum pain. If these associations are complex to explain due to the incomplete understanding of their physiopathology,

Table 5 Prevalence of oral-related impacts during scuba diving reported in the literature

	Taylor et al. 2003 [29]	Al-Hajri et al. 2006 [30]	Jagger et al. 2009 [10]	Zanotta et al. 2013 [28]	Gunepin et al. 2015 [26]	Aldridge et al. 2004 [31]	Present study 2020
Population	American and Australian civilian divers	Saudi-Arabian and Kuwaiti military divers	Australian civilian divers	Swiss civilian divers	French military divers	English civilian divers	French civilian divers
N	709	127	125	520	1317	63	1015
Prevalence							
Barodontalgia	9.2%	17.3%	21.6%	10.2%	7.3%	NR	10.8%
Dental fracture	NR	NR	0.8%	6.3%	4.4%	NR	4.6%
Mouth syndrome	NR	NR	16.8%	11.3%	NR	26%	13.4%
Gum pain	NR	NR	NR	6.5%	0.8%	NR	2.8%

NR not referenced

we can hypothesize that a repetition of deep and saturating dives would expose dental tissues to barometric and thermal stress that would irritate the dental pulp. Indeed, divers with a high level of practice often dive deeper and more times than less skilled divers. Furthermore, Calder and Ramsey suggested an influence of gas mixture in the manifestation of barodontalgia and barotrauma [8]. Actually, they explained that the use of helium during deep dives would decrease the viscosity of the inspired air. This would lead to air infiltrations into the tooth that would be trapped during the descent and secondary cause barodontalgia and barotrauma in ascent [33]. Moreover, the cryogenic action of helium would also increase dental sensitivity during dives. Cohort studies with the use of different employed gas mixtures might be interesting to follow regarding their influence on oral events during diving activity.

Regarding participants' characteristic and significant associations, the youngest participants had a lower diving level, which seems logical. Women, being younger (Table 1), therefore, also have a lower level. Regarding the results of the logistic regression (Table 4), it seems that the prevalence of oral-related conditions in scuba diving is higher among older people, with the notable exception of mouth syndrome which is less reported by older men. However, women being younger, and younger people being of low diving levels and using less prevention, an interaction between gender and level of diving could have been at play. No significant association was yet found, and diving level had low to no association with studied pathologies in regression models, likely because the effect was mediated by age.

Prevention and information

Concerning oral problem prevention during scuba diving, even less data is available in the literature. To our knowledge, our study is the first one to investigate this issue. It highlighted the major place of diving trainers and the relevance of the FFESSM program in the initial awareness of practitioners about oral health-related problems in diving. Divers felt like they have benefitted from high quality information within their sport community. These stakeholders seem to play a major role in this prevention task, and especially to refer divers to health professionals.

Nevertheless, when it came to specific topic of prevention like anatomic mouthpieces, the preventive information remained incomplete, with only 12.9% of the 1015 divers who were informed of their existence. This reflects a lack of knowledge about preventive tools that are available to divers. Thus, such specific topics require the expertise of an oral health professional to complete divers' initial awareness. Therein, dentists should be called upon more often, while they are actually positioned as the second intermediary of prevention regarding oral problems linked to diving. Less than half of the respondents proceeded to a dental visit before a diving season, even though dental visits seem to be beneficial in terms of preventive effectiveness for these problems. As a matter of fact, divers who completed a dental examination before a diving season reported fewer oral-related problems compared to those who did not, with non-significant results, however (Table 3).

Young people, and thus less-leveled divers, were less likely to use prevention. A hypothesis for some of their higher orofacial problems risks (mouth syndrome or gum pain for example) may then be that they declined to use the dental advisory. Classically, women tend to be more diligent when it comes to health advisory; in our study, however, there was no difference between men and women regarding the attendance of prevention, even if men were globally of higher diving levels, and these high-leveled divers were more likely to attend dental advisory.

To encourage recourse to the dentist, different options can be considered, such as the development of communication tools in diving centers (posters, short video clips, etc.) to inform the practitioners about the benefits of a

dental examination in the context of scuba diving, and to encourage them to talk about their sport activity with their dentist.

Furthermore, on the dentist's side, the integration of an item about sports activities in the systematized medical questionnaire would be strategic to identify patients practicing oral health risk-related sports. This would facilitate access to preventive information provided by the dentist. Indeed, since 35.2% of our sample had not been informed by their dentist that specific dental care was required to practice scuba diving, dentists should enquire if their patients do practice scuba diving to tell them about the risks.

Finally, and in relation to this last point, the study showed that divers were not always sufficiently informed by their dentist of the preventive measures specific to their activity. Therein, the development of sports dentistry, and especially items about the relation between diving and oral health, during the initial and particularly the continuous training should be developed. Systematically giving complete information to divers would secure them in their practice and make them actors of their own health.

The prevalence of oral problems in scuba diving is far from being negligible and their consequences may compromise the safety of divers. As for TMD symptoms, women and young divers are particularly exposed to mouth syndrome. The prevalence of dental fractures caused by shocks and barotrauma increases with age and thus could be associated with a higher number of dental restorations. An advanced level of graduation in diving is associated with a higher prevalence of barodontalgia, dental barotrauma and gum pain, that could be explained by a repetitive thermic and barometric stress in deep dives as well as by the influence of some gas mixtures. However, further studies have to be carried out to validate these hypotheses.

Our study reveals an effective awareness about orofacial-related problems among divers, raised by the diving centers during the formation. However, we noticed that dentists are not sufficiently solicited, which leads to incomplete information especially regarding anatomic mouthpieces. Divers who went to their dentist before the start of their diving season show significantly fewer oral problems during their scuba diving practice. Therefore, divers should be encouraged to consult more their dentist to prevent orofacial problems in scuba diving.

Author contributions All the authors contributed to the study conception and design. Material preparation and data collection were performed by P-AM and DO, analysis was performed by P-AM, GFDG and DO. The first draft of the manuscript was written by P-AM and was reviewed and edited by GFDG, DO and A-MM. All the authors commented on previous versions of the manuscript. All the authors read and approved the final manuscript.

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was submitted to the Ethical Committee of the University Hospitals of Strasbourg, France, and received the authorization n°CE-2020-145. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent Informed consent was obtained from all individual participants included in the study.

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