Before commencing this autopsy x-ray films were taken and these showed air in the heart and the major arteries in the neck. There was frothy pink fluid in the trachea and bronchi, similar to that which could be expressed from the cut surfaces of the lungs, but there was no histological evidence of pulmonary barotrauma in the lung sections examined. The cerebral vessels contained large blebs of air. Death was due to air embolism into the brain (CAGE).

Examination of the tank showed it was down to the reserve pressure and the reserve was "on" so no air was available for use by the victim. It is probable that nitrogen narcosis had effected his alertness to his situation. His deep diving experience is not on the record.

TRAINED, APPARENTLY EXPERIENCED. CALM SEA. BOAT DIVE. 36 M. DEEP DIVING EXPERIENCE NOT STATED. SEPARATED DURING ASCENT. FOUND UNDERWATER, UNCONSCIOUS. RETAINED WEIGHT BELT. NO AIR AVAILABLE. FAILED TO INFLATE BUOYANCY VEST. BUDDY SURFACED AND ANOTHER FOUND BODY. LOW ON AIR BUT DID NOT OPERATE RESERVE. NITROGEN NARCOSIS PROBABLE. CAGE.

DISCUSSION

The three breath hold diving fatalities show a remarkably unusual diversity of critical factors. The risk of drowning if an epileptic should have a "turn" while in the water is obvious when considered in the abstract but must appear slight to someone with only rare attacks. This case was particularly unfortunate because his friends were attempting to keep a safety watch on him. It was probably unwise to allow an epileptic having recent break-through attacks while on therapy to go swimming but there was no evidence that he was told this (or that he was not so advised). As in most instances where the victim's previous health may be significant, the records fail to cover all matters of interest because inquest investigations are intended to find the cause of unexpected deaths rather than be an investigation into every detail of the critical path of the incident. Epilepsy, particularly if poorly controlled, must be regarded as a contraindication to in-water activities.

The shark attack was totally unexpected and a tragic reminder that on rare occasions a "rogue" shark may show the power of this species. The possible significance of burleying to attract sharks for the amusement of big game fishermen must remain undecided. The third case is a reminder of the factor one cannot afford to ignore, the power of the sea.

In the group of scuba diving related fatalities there are several factors whose significance deserves fresh consideration:

a. Buoyancy vests relying on the tank air will not function if there is insufficient available air pressure in the tank.

b. Resuscitation is particularly difficult if there is profuse froth or vomit coming from the victim's mouth.

c. It can be very difficult to pull an unconscious person into a boat unaided.

d. Cardiac health factors are not necessarily predictable.

e. Nitrogen narcosis impairs correct responses by the diver.

f. Equipment problems, though rare, can occur devastatingly.

g. Water flowing towards and through exit pipes in dams exerts irresistible pressures at the pipe entrance.

h. Entanglement need not be extreme to be fatal if the diver is alone.

i. Air embolism can occur without the victim surfacing. Many people believe that air enters the circulation only when lung overpressure is relieved on taking a breath after surfacing. This is incorrect. From the autopsy results of cases SC 85/8 and SC 85/10 and the previously reported case RB 83/1[1,2] is apparent that air embolism can occur as a result of ascents which never approach the surface. Two such cases were reported by Harpur.[3] No other published autopsy reports of such incidents have been traced.

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PROJECT STICKYBEAK

This is an ongoing confidential investigation seeking to collect information relating to all severities and types of diving-related events. Correspondence giving information or commenting on case reports is welcomed.

DIVING AND DENTAL PAIN

RS Hobson

Scuba diving is one of the most rapidly growing adventure sports today, and this, together with the use of divers in industry, especially for oil exploration, has resulted in a great deal of medical research into the physiology of diving, usually in order to achieve longer and deeper dives for the professional diver. More recently, attention has focused on the problems encountered by the sports diver, and a number of papers[1,2,3,4,5,6] describe disorders of the ears, nose and sinuses. A few papers[7,8,9] describe dental problems

suffered by divers. Despite the reported incidence in diving manuals[10] these tend to be of a general nature and are based upon observations by the authors. As there have been no studies into the aetiology of diving-induced dental pain, it was considered worthwhile conducting a survey to obtain information from individuals who had suffered pain whilst diving and to use this information to determine the aetiological factors involved in orofacial pain during diving.

METHOD

A questionnaire was designed to collect data relating to diving experience (number of years diving, number of dives and qualifications); diving equipment used; dental history; dental pain whilst diving, its severity and treatment, if any. The questionnaire was circulated to the members of the British Sub-Aqua Club through its magazine 'Diver'. This method of data collection obviously produced a self-selected sample. There were 74 questionnaires returned, 62 male and 12 female. The data was processed on the University of Newcastle upon Tyne's Amdahl 5860 mainframe computer using the Statistical Package for Social Sciences.

RESULTS

The type of pain experienced can be divided into two groups, tooth-ache and myo-fascial pain dysfunction (MFPD), also known as temporomandibular joint (TMJ) dysfunction. This is a condition of musculo-skeletal discomfort, or dysfunction, in the masticatory system which is aggravated by chewing or other jaw use. It is unrelated to local disease involving the teeth and mouth.[11] MFPD was reported in 52 cases and toothache in 24. There were 19 reports of pain from both MFPD and tooth-ache. 17 questionnaires reported no pain at all and these were excluded from the analysis reported in this paper.

TABLE 1

RESPONSES TO QUESTIONNAIRE

MFPD only	33
MFPD and toothache	19
Toothache only	5
MFPD (all cases)	52
Toothache (all cases)	24
No pain	17

MYOFACIAL PAIN DYSFUNCTION

Of the 76 cases of reported pain MFPD was the causative factor in 52 cases (68.4 per cent). Within this MFPD group, 33 per cent (17 cases) reported that they suffered MFPD from non-diving activities eg. yawning and chewing, as well as when diving. This level of 33 per cent would seem to be about the level of MFPD occurring in the general population, Rugh and Solberg[12] reporting that 1 in 4 of the population are aware of symptoms, but incidence can be as high as 86 per cent upon clinical examination.

Comparison of MFPD experienced with individual makes of mouthpieces (Figure l) suggests that certain mouthpiece designs are more likely to cause MFPD. Mouthpieces that have been modified or specially made for the individual had the lowest incidence of MFPD. This would seem to confirm findings[13,14] that lack of posterior support from the mouthpiece is a significant factor in MFPD associated with diving. The most common site for discomfort or pain was in either or both of the masseter muscles which occurred in 36 cases, 12 divers reported TMJ dysfunction pain (23 per cent). Four divers reported other facial muscles as the site of pain (7 per cent). Ingruall and Warfringe[15] measured EMG activity in muscles when biting on a diving mouthpiece. They found that masseter activity varied significantly with the type of mouthpiece used. This suggests that with the present design of mouthpieces commercially available, in which the interdental bite blocks are gripped by the canine and premolar teeth (Figure 2), there is a lack of posterior support, causing abnormal loading of the muscles and TMJ. This problem can be remedied by careful mouthpiece design. Goldstien[16] and Mack et al[17] have shown that repositioning of the interdental bite block posteriorly gives a more even loading of the TJM and facial musculature, causing a significant decrease in the incidence of MFPD experienced while diving (Figure 3).

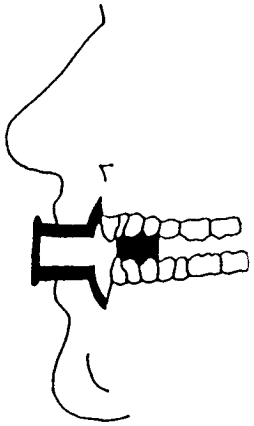


FIGURE 2

Position or the mouthpiece on the dentition showing the lack of posterior support

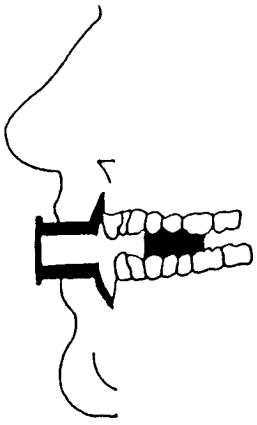


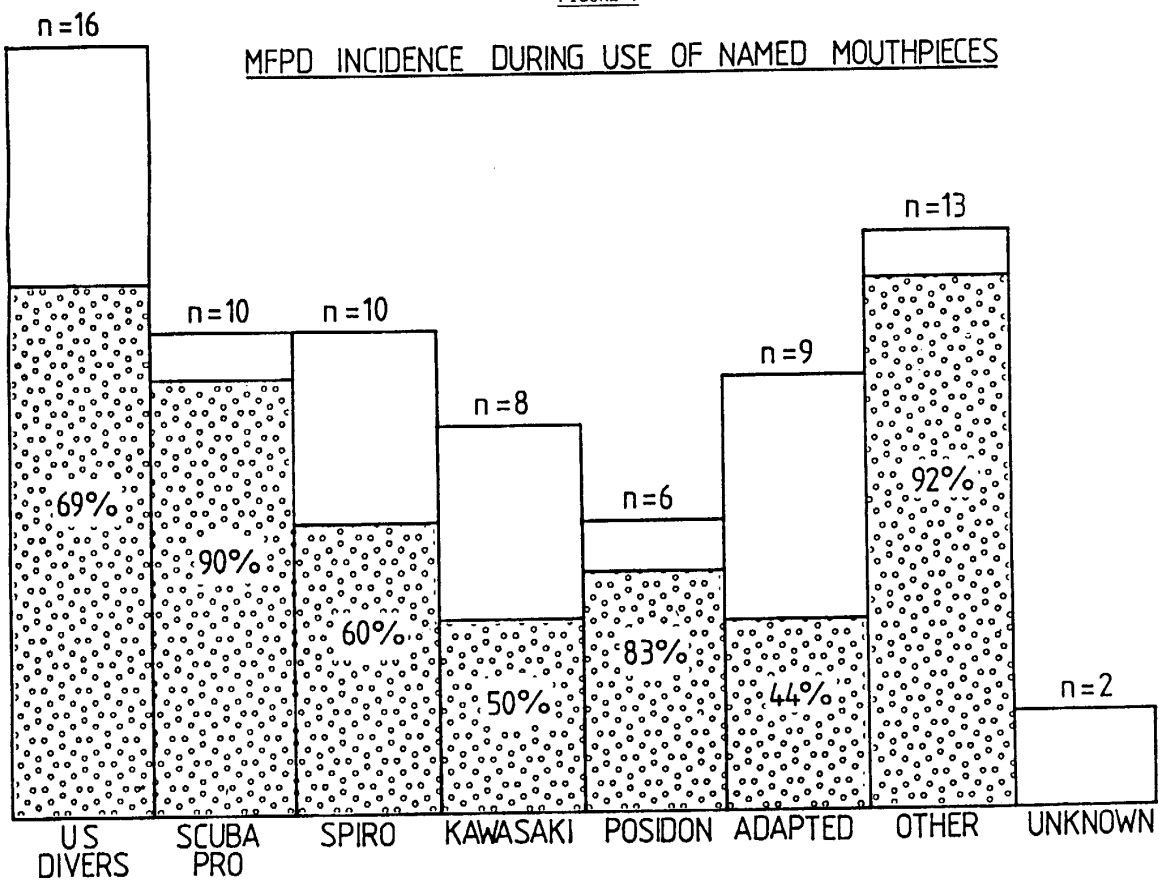
FIGURE 3

Ideal position of the mouthpiece, the interdental bite block giving even loading across the dentition

TOOTHACHE

In the 24 incidences of toothache reported, there was only one report of a filling being lost whilst diving. This would seem to indicate that this is an unusual occurrence, although it is reported as a dental hazard of diving.[6] Calder and Ramsey[18] exposed teeth to rapid decompression from a pressure of 150 psi, which is about twice that acting on a scuba diver at a depth of 50 metres, the maximum recommended for sports diving, where the ambient pressure is 6 atmospheres absolute (6 times atmospheric pressure or 88 psi). They found that only carious teeth or those with deficient restorations failed under decompression. These results suggest that for a tooth to fail in this extreme manner, it must be already compromised in some way prior to failure.

FIGURE 1



Orban and Ritchey[19] demonstrated gas bubble formation in partially necrotic pulps in teeth extracted following pain during decompression or high altitude flight. They concluded that teeth with normal pulps will not cause pain under decompression whether the tooth is intact, carious or filled.

n 5 divers (25 per cent of those with toothache) the pain was severe enough for the dive to be abandoned. The rest had less severe pain and continued the dive as planned.

Of the reported cases of toothache,[10] (41.7 per cent) were suffering from a cold or sinusitis at the time of the incident (Table II). This complements Schiller's[20] results, which suggests that maxillary sinusitis has an important role in the aetiology of diving pain. This problem is easily overcome by medical care and the recommendation not to dive whilst suffering from cold or sinusitis.

TABLE II

CAUSES OF TOOTHACHE

Cold or Sinusitis	10 (41.7%)
Compromised Teeth and Treatment	8 (33.3%)
Pain. No Treatment Sought	6 (25.0%)

8 divers (33.3 per cent) had a compromised tooth which required some form of dental treatment varying from a simple filling to extraction of the tooth. The remaining 6 (25 per cent) assessed the pain as tolerable and did not seek medical or dental treatment, attributing the cause of pain to temperature changes experienced whilst diving.

Beynon[21] in a study of the effects of arctic conditions on tooth and cheek temperature, reported that a drop of 11°C (from 36°C to 25°C) occurred in the internal cheek temperature upon exposure to an air temperature of -10°C. This was reflected in a drop in tooth surface temperature of 0°C below the normal 36.5°C. Temperatures experienced by divers are higher than this as the winter sea temperature around the British Isles is about 6°C. However, the greater heat conductivity, and therefore cooling effect, of water compared to air may have a significant effect upon internal cheek and tooth surface temperatures. This may explain the cause of this form of mild pain.

CONCLUSIONS

Dental pain associated with diving is of multifactorial aetiology. The major causes seem to be MFPD due to the use of a diving mouthpiece, the design of which should permit the maximum safety, utility and comfort for the diver. These results suggest that some mouthpieces are better in the prevention of MFPD than others and that a diver experiencing symptoms should try a number of different mouthpieces, or consider having one specially constructed.

In the prevention of toothache, the maintenance of a healthy dentition cannot be overemphasised, as some of the causative factors, eg. tooth decay or leaking restorations, can be prevented by timely dental intervention. The problem of thermal changes causing

toothache is not a new one, as tooth sensitivity to hot or cold is well recognised. In such cases no specific guidelines can be given, but a thorough dental examination should be carried out in order to eliminate the possibility of dental caries or fractured teeth. The application of desensitising agents by a dental practitioner may relieve the symptoms.

It is important that with the wide range of presenting symptoms[1] of diving dental pain that the medical practitioner should include the possibility of a dental cause in his or her differential diagnosis, when examining a diver suffering from ear, sinusitis or MFPD pain.

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ARTICLES OF INTEREST PUBLISHED IN OTHER JOURNALS

The Medical Journal of Australia, Double Christmas Issue (December 1/15, 1986, Vol 145, No. 11/12) contained three articles of interest to divers, swimmers and tourists. They are

1. An editorial, "What on earth is ciguatera?", by Struan Sutherland (pages 557-558).

2. "Further understanding of, and a new treatment for, 'Irukandji' (Carukia barnesi) stings", by Peter J Fenner, John Williamson, Vic I Callanan, and Ian Audley (Pages 569-574). The abstract accompanying the article reads as follows.

> A brief analysis is presented of the large recorded numbers of swimmers who have been stung by the "Irukandji" (Carukia barnesi) jellyfish during the 1985-1986 summer season in north Queensland, and the results are discussed. Many of the victims may suffer from symptoms of over-stimulation of the sympathetic system, and hypertension is shown to be another complication of this syndrome. This hypertension seems to respond well to intravenously-administered phentolamine, an alpha-adrenergic receptor blocking drug. Phentolamine also reduces the excessive shaking and sweating that appears to be part of the "Irukandji syndrome". Diazepam relieves the anxiety which is part of the syndrome, but antihistamine agents and hydrocortisone seem to have no beneficial effect.

(Med J Aust 1986; 145: 569-574)