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Oral Health Complications of SCUBA Diving

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Summary

OBJECTIVE

This review aims to assess the specific oral health complications associated with SCUBA diving, including barodontalgia, barosinusitis, and temporomandibular joint (TMJ) disorders, and to examine the dental implications of hyperbaric oxygen therapy (HBOT) used in decompression sickness treatment. Additionally, this review identifies gaps in the literature and suggests areas for further research to improve dental care guidelines for divers.

MATERIALS AND METHODS

A systematic literature search was conducted using PubMed and Scopus databases from 2004 to 2024, focusing on terms such as "barodontalgia," "dental barotrauma," and "diving dentistry." From 77 initial articles, 25 studies were selected based on relevance to pressure-induced oral complications, diving-related barotrauma, and dental management for SCUBA divers.

RESULTS

The review identifies barodontalgia as a prevalent issue, commonly triggered by untreated caries or defective restorations, with symptoms intensified by pressure changes. TMJ disorders, linked to prolonged clenching on diving mouthpieces, and sinus-related barotrauma also emerged as significant concerns. Preventive measures, including regular dental checkups, use of resin-based cements, and customized mouthpieces, are recommended to reduce risks. Furthermore, the review highlights a need for larger, controlled studies across diverse diver populations to validate current recommendations and develop accessible guidelines, especially for recreational divers who may lack access to specialized dental care.

Keywords :barodontalgia, dental barotrauma, diving dentistry, barosinusitis

Introduction

Given the immense popularity of self-contained underwater breathing apparatus (SCUBA) diving and its rapid growth over the past decade, with approximately one million certifications issued annually by the Professional Association of Diving Instructors (PADI), dental practitioners are increasingly likely to encounter patients who dive [1-4]. This growing interest in diving has prompted extensive research into the specific oral health complications associated with the sport. Conditions such as diving-associated headaches (e.g., migraines and tension-type headaches), barosinusitis, barotitis media (sinus and middle ear barotrauma), and barodontalgia (pressure-induced dental pain) are particularly relevant for dental professionals [1]. In addition to barotrauma affecting the head, face, and sinuses, divers may experience nerve-related complications, such as trigeminal (CN V) or facial (CN VII) nerve baroparesis, which can lead to pressure-induced palsy in severe cases.

As a diver descends, ambient pressure increases, reaching up to four times the pressure at the surface when diving at 30 meters, which significantly impacts the oral and maxillofacial regions [2]. These intense pressure variations also affect TMJ stability, particularly due to prolonged clenching on mouthpieces, and can lead to dental trauma. Moreover, divers are at risk of decompression sickness (DCS), a potentially serious condition that occurs when dissolved gases, mainly nitrogen, form bubbles in the tissues upon rapid ascent. To manage DCS, HBOT in a pressurized chamber is commonly used to help eliminate these gas bubbles and promote recovery. However, HBOT itself can present dental risks, as the pressure changes within the chamber can destabilize dental implants, exacerbate barodontalgia, and potentially affect restoration integrity if decompression is not controlled gradually.

This review systematically examines SCUBA diving complications related to pressure-induced trauma in the head, face, and oral regions and evaluates TMJ conditions associated with diving mouthpieces. The objective is to provide dental and medical professionals with a comprehensive understanding of the maxillofacial health risks linked to SCUBA diving and HBOT, enhancing their ability to diagnose and manage these conditions effectively.

Materials and Methods

A literature search was performed using the PubMed and Scopus databases, spanning from 2004 to 2024. The search incorporated the keywords "barodontalgia," "dental barotrauma," and "diving dentistry," resulting in 77 articles. Of these, 52 studies were excluded for either addressing other pressure-related risks, such as those associated with high altitudes rather than SCUBA diving, or for being unrelated to the topic. Ultimately, 25 papers were selected for inclusion in this review.

Results

1. Barodontalgia

Barodontalgia, a form of dental pain induced by changes in atmospheric pressure, presents as a significant challenge for individuals frequently exposed to pressure fluctuations, including divers, aviators, and hyperbaric chamber occupants. This pain arises primarily due to trapped gas in dental spaces or defects within restorations, often exacerbated by existing dental pathologies such as caries, periapical infections, and failing restorations [5]. The onset of barodontalgia is frequently noted in upper teeth, with first molars being particularly susceptible due to their structural and positional characteristics. Studies have shown that the prevalence of barodontalgia can reach up to 17% among military divers, contrasting with a lower prevalence in the civilian population [6].

Mechanistically, barodontalgia is influenced by Boyle's Law, which posits that the volume of gas is inversely proportional to atmospheric pressure under a constant temperature. This principle explains why gas trapped in dental defects, such as fillings or endodontically treated teeth, expands as external pressure decreases, leading to pain and, in some cases, odontocrexis (tooth fracture) [7, 8]. The pressure-induced expansion of gas can compress dentinal tubules and the dental pulp, exacerbating pain during ascent [6]. Additionally, indirect barodontalgia may arise from middle ear or sinus barotrauma, referring pain to the dental region [5].

The diagnosis of barodontalgia poses a distinct challenge, primarily due to the inability to replicate barometric conditions within a standard dental clinic. As a result, accurate diagnosis relies on comprehensive patient history and detailed clinical examination, incorporating sensitivity tests, radiographs, and possibly advanced imaging such as computed tomography. These diagnostics help distinguish barodontalgia from similar conditions like carious lesions, pulpitis, and TMJ disorders [7, 9]. García-Torres and Segura-Egea [6] emphasize that defective fillings are a common precursor to barodontalgia, accounting for as many as 84% of cases, underscoring the importance of rigorous restorative assessments.

The Fédération Dentaire Internationale (FDI) has developed a classification system for barodontalgia, distinguishing cases based on pain origin and symptomatology. Direct barodontalgia is attributed to dental or periapical pathology, while indirect cases stem from barosinusitis or related sinus issues. This classification aids in determining the appropriate treatment approach, especially as symptoms may vary depending on the nature and direction of pressure changes [6, 9]. Pain during descent typically suggests pulp necrosis, whereas pain on ascent may indicate pulp vitality, with possible irreversible pulpitis if pain persists post-pressure change [5, 6].

Preventive strategies play a critical role in mitigating the risk of barodontalgia, especially among high-risk groups. The FDI and multiple studies emphasize the importance of regular dental checkups, thorough dental treatment, and addressing predisposing factors like untreated decay and poorly adapted restorations [7]. Dentists often recommend resin-based cements over materials such as zinc phosphate or glass ionomer cements, as resin exhibits minimal microleakage and maintains bond integrity under pressure [7, 9]. For military or frequent divers, specific guidelines suggest ceasing diving activities shortly after oral surgery to prevent barotrauma-related complications, with recommended wait periods ranging from one to four weeks based on the procedure's nature and healing status [5, 10].

2. Barosinusitis

Sinus barotrauma, or barosinusitis, is a common complication in divers, occurring due to sinus outflow obstruction during rapid ambient pressure changes, often linked to conditions like rhinosinusitis [7]. Common symptoms include pain during descent and ascent, epistaxis, and associated middle ear barotrauma. An Australian Navy study involving 50 divers found that over half experienced these symptoms, with some reporting a "popping" sensation likely caused by mucosal damage at depth [11, 12]. The severity of barotrauma is influenced by factors like sinus anatomy, ostia size, and the rate of pressure change. In severe cases, specific sinuses, such as the sphenoid, may be affected, leading to retro-orbital pain or, in rare cases, optic nerve damage or blindness due to sinus mucocoele compression [13, 14].

Prevention of sinus barotrauma emphasizes avoiding diving during respiratory infections and refraining from using vasoconstrictors shortly before diving to prevent rebound congestion [13]. Treatment options include saline irrigations, decongestants, corticosteroids, and, for persistent symptoms, endoscopic sinus surgery. Divers may resume diving six weeks after full sinus resolution is confirmed by imaging [15, 16]. Comprehensive evaluation, including endoscopic and imaging assessments, is essential for divers with recurrent barotrauma, especially those with underlying sinus pathologies, to prevent further episodes and improve outcomes.

3. Temporomandibular Joint Consequences

Temporomandibular joint (TMJ) disorders are increasingly recognized in scuba divers due to the prolonged and intense use of diving regulator mouthpieces, which can exacerbate existing TMJ dysfunction [7]. Diving mouthpieces, typically silicone rubber, require an anterior mandibular position and isometric contraction to maintain stability, leading to uneven TMJ loading and discomfort, particularly in divers predisposed to TMJ issues. Common symptoms of diving-induced TMJ dysfunction (TMD) include pain, fatigue, clicking, headaches, and even tinnitus [17]. Studies indicate that up to 65% of divers experience TMD, often due to the continuous force needed to retain the mouthpiece in challenging conditions [18].

Factors contributing to TMD during diving include mouthpiece quality, diver inexperience, and habits such as bruxism, which can increase muscle tension and TMJ stress [7, 19]. Muscle fatigue, particularly in the masseter, temporalis, and pterygoid muscles, is often caused by prolonged clenching needed to balance the regulator, especially in strong currents or during extended dives [19]. While customized mouthpieces are recommended to reduce strain, commercially available designs have shown limited effectiveness in mitigating TMD symptoms [7]. Management of diving-related TMD involves both preventive and therapeutic approaches, including the use of a custom mouthpiece, soft diets, massage, and, in severe cases, non-sedating muscle relaxants and anti-inflammatory medications to relieve muscle and joint discomfort.

4. Dental Consequences of Treatment in Hyperbaric Chambers

Hyperbaric oxygen therapy (HBOT), widely used to treat decompression sickness (DCS) resulting from diving, involves exposure to high-pressure oxygen, typically around 2.4 bar, to increase tissue oxygenation and accelerate recovery [20]. However, this high-pressure environment can pose risks to dental health, particularly due to rapid pressure fluctuations within the chamber. For instance, HBOT can destabilize dental implants, as demonstrated by Özyurt [20], who found a slight but statistically significant reduction in implant stability after 5 to 7 HBOT cycles. This destabilization is likely due to microstrains introduced into the bone-implant interface during repeated compression and decompression cycles, which can compromise implant integrity. Furthermore, improper decompression rates can heighten risks of dental barotrauma, underscoring the need for gradual decompression protocols to minimize adverse dental effects.

5. Recommendations for Dental Treatment in SCUBA Divers

For SCUBA divers, dental treatment protocols must consider the unique risks posed by pressure fluctuations, particularly regarding barodontalgia and restoration stability. Garcia-

Torres et al. [6] emphasize that divers with existing caries or defective restorations are at heightened risk for barodontalgia, making thorough caries removal and adequate restoration, ideally with resin cement, essential. For deep restorations, using a cavity base, such as glass ionomer, is advised to protect the pulp from pressure-induced microleakage. When pulp exposure is present, root canal treatment using hot gutta-percha in a single session is recommended to reduce the risk of air entrapment.

Pressure cycling impacts dental materials differently; research indicates that crowns cemented with resin or resin-reinforced glass ionomer maintain better retention under pressure than those using zinc phosphate or traditional glass ionomer cements [21, 22]. For restorations, applying a flowable composite or resin-modified glass ionomer liner can significantly reduce microleakage in high-pressure environments. Additionally, composite generally exhibits better fracture resistance under diving pressures than amalgam, making it a preferable choice [22-24].

Orthodontic and endodontic treatments also require adjustments for divers exposed to pressure changes. Composite resin is preferred over resin-modified glass ionomer for bracket bonding, as the latter loses retention under pressure. In endodontics, vertical condensation offers superior sealing for divers frequently exposed to pressure variations [25, 26]. These tailored materials and techniques help mitigate the effects of underwater pressure on dental treatments, enhancing safety for divers.

Conclusion

The growing popularity of SCUBA diving has underscored the need for awareness among dental professionals regarding the unique oral health challenges divers face. This review highlights key conditions, including barodontalgia, barosinusitis, and temporomandibular joint (TMJ) disorders, all exacerbated by underwater pressure changes. Barodontalgia, often linked to underlying dental issues like caries or defective restorations, remains one of the most

prevalent dental complications, while barosinusitis and TMJ disorders are also common due to prolonged clenching on diving mouthpieces and sinus pressure fluctuations. Preventive measures, including resin-based materials, customized mouthpieces, and managing pre-existing dental issues, play a crucial role in mitigating these risks and maintaining diver comfort and safety.

This emphasis on preventive care is further supported by the findings of Onose et al. (2020) [27], who observed that divers experiencing tooth pain during dives were significantly more likely to have skipped preventive dental visits in the previous year, with an odds ratio of 2.76 (95% CI: 1.12-6.80). These findings underscore the importance of regular dental checkups to detect and address potential issues before they are exacerbated by pressure changes underwater, thereby improving safety and comfort for divers.

In addition to diving-specific concerns, hyperbaric oxygen therapy (HBOT), commonly used to treat decompression sickness (DCS), presents further considerations for dental health. While HBOT significantly aids recovery by reducing nitrogen bubbles in tissues, it can destabilize dental implants and contribute to dental barotrauma if pressure changes are not adequately managed. This makes it imperative for treatment protocols to incorporate gradual decompression to minimize adverse effects.

For treatment planning, selecting materials that withstand pressure variations—such as resin and resin-reinforced glass ionomer cements—and techniques like vertical condensation in endodontics are essential. These tailored approaches, informed by diving-specific dental research, can help practitioners offer more effective and durable solutions for divers. By implementing these recommendations and emphasizing preventive care, dental professionals can significantly enhance oral health outcomes for patients engaged in SCUBA diving and other high-pressure activities.

Discussion

This review highlights important oral health challenges for SCUBA divers, yet several limitations in existing research deserve consideration. Many studies rely on small samples or case reports focused on military divers, which may not generalize well to recreational divers [6,18]. Recommendations for regular checkups and pressure-resistant materials, while valid, may be impractical for divers in remote areas with limited access to specialized care [27]. Moreover, recommendations for TMJ strain relief through custom mouthpieces lack robust clinical evidence, as few studies rigorously compare these with standard designs [7]. Additionally, findings on HBOT's impact on dental implants are primarily based on simulations rather than clinical studies, which limits their real-world applicability [20].

In sum, this review provides valuable insights but highlights the need for larger, controlled studies across diverse diver populations to develop more accessible, evidence-based guidelines for both recreational and professional divers.

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