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Microplastics in Dentistry: A Narrative Review on Sources, Risks, and Sustainable Practices

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ABSTRACT:

Microplastics (MPs), defined as plastic particles less than 5 mm in size, are pervasive environmental contaminants with significant ecological and health implications. While much attention has been focused on the presence of microplastics in marine environments, air, and food chains, their occurrence and generation in healthcare settings, particularly in dentistry, have received limited investigation. Dentistry relies heavily on synthetic materials, including resin composites, acrylics, and impression materials, which contribute to microplastic generation during clinical procedures such as grinding, polishing, and trimming. Additionally, single-use plastic items, digital technologies, and improper waste disposal practices further exacerbate the problem. This narrative review explores the various sources of microplastics in dental practice, including dental materials, clinical procedures, and waste management, highlighting their potential routes of human exposure and environmental impact. Microplastics generated in dental settings may enter the body through inhalation, oral contact, ingestion, or even systemic absorption via nanoplastics, posing unknown long-term health risks. Furthermore, the environmental consequences are significant, with MPs contributing to pollution in waterways, landfills, and ecosystems, where they can accumulate in food chains and affect biodiversity. To address these concerns, the review discusses several strategies for reducing microplastic pollution, including the adoption of eco-friendly materials, the implementation of waste filtration and water management systems, and the reduction of single-use plastics. Additionally, the need for education and training among dental professionals, as well as research and regulatory changes, is emphasized to promote sustainable practices. Ultimately, this review underscores the importance of addressing the dental sector's role in microplastic pollution, offering practical solutions to help reduce its environmental footprint and improve sustainability in dental practice.

1. Introduction

Microplastics (MPs), broadly defined as synthetic polymer particles smaller than 5 mm, have become a ubiquitous presence in modern ecosystems. They can be classified into two major categories: primary microplastics, which are manufactured at microscopic sizes for specific uses (such as in cosmetics and industrial abrasives), and secondary microplastics, which result from the degradation and fragmentation of larger plastic debris due to mechanical, photolytic, or biological processes [1]. In recent years, increasing scientific attention has been directed toward understanding the scale and consequences of microplastic pollution. MPs have been detected in marine and freshwater ecosystems, soil, air, and even within living organisms—including humans [2–4]. These particles are not merely inert debris; their small size allows them to be ingested, inhaled, or absorbed, raising concerns about their biological interactions, potential for cellular toxicity, and long-term health consequences.

Despite this growing body of evidence, the contribution of the healthcare sector—especially dentistry—to microplastic contamination remains underrepresented in scientific discourse. Dentistry is inherently reliant on a

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variety of polymer-based materials and devices. Restorative materials such as resin composites, dental cements, acrylics used in prosthodontics, and impression materials are all synthesized from complex polymer matrices like PMMA (polymethyl methacrylate), Bis-GMA (bisphenol A-glycidyl methacrylate), and UDMA (urethane dimethacrylate) [5,6]. The clinical manipulation of these materials—through mixing, curing, finishing, and polishing—can lead to the formation of microparticles and nanoplastics that are not easily captured by conventional waste handling systems. Moreover, daily dental procedures, from crown preparation to denture adjustments, frequently involve high-speed rotary tools that generate fine plastic particulates.

Equally problematic is the widespread use of single-use plastics in dental settings, encompassing gloves, suction tips, plastic trays, syringes, sterilization pouches, and patient bibs. While these products serve critical roles in infection control and efficiency, improper disposal and lack of waste segregation often result in plastic waste entering landfill sites or aquatic systems, where it can break down into microplastics. A particularly overlooked source is dental wastewater, which may contain unfiltered microplastics from finishing procedures, impression material residues, and excess dental cement. Many dental practices lack specialized filtration systems capable of capturing such fine particles, allowing them to flow directly into municipal wastewater systems [7].

Another emerging area of concern is digital dentistry, including CAD/CAM milling, 3D printing, and digital impression systems, which, while revolutionizing care delivery, also introduce new types of polymer-based waste. Uncured resin residues, plastic supports, and waste material from failed prints or discards contribute to the environmental burden if not managed responsibly [8].

The health implications of microplastics are still being unraveled, but preliminary studies suggest they may trigger inflammatory responses, oxidative stress, and even endocrine disruption in biological tissues [9,10]. These findings underscore the need for a more comprehensive understanding of occupational exposure, particularly for dental professionals who may be at increased risk of inhaling or handling microplastic-laden dust on a regular basis. Given the intimate proximity of dental procedures to the oral and respiratory pathways, it is plausible that both clinicians and patients face exposure risks, although this has not yet been adequately quantified in dental settings.

In parallel, sustainability in dentistry has become an urgent consideration. The World Health Organization (WHO), United Nations, and several national health systems now emphasize green healthcare practices as a part of their broader environmental and public health strategies. Dentistry, as a visible and material-intensive branch of medicine, must reconcile the need for clinical effectiveness with ecological responsibility. Fortunately, innovations in biodegradable materials, environmentally conscious product design, and water treatment technologies offer pathways for meaningful reform—if supported by research, policy, and education.

This narrative review aims to fill a critical gap by exploring the intersection between dentistry and microplastic pollution. It will synthesize current findings on:

- The sources of MPs generated within dental practice
- The potential human exposure routes unique to clinical settings
- The broader environmental impact of dental microplastics
- And strategies to mitigate this emerging form of pollution through sustainable practices and policy-driven change

By shedding light on a rarely discussed issue, this review aims to encourage further investigation, spark dialogue within the dental community, and promote actionable steps toward a more environmentally responsible practice of dentistry.

2. Sources of Microplastics in Dentistry

Dentistry is inherently material-intensive, relying heavily on synthetic polymers and plastic-based products for both therapeutic and logistical functions. These materials, while offering advantages in durability, aesthetics, and functionality, contribute to microplastic (MP) generation through various clinical and non-clinical processes. The sources of MPs in dental practice can be broadly categorized into the following: dental

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materials, mechanical procedures, single-use plastics, digital/3D printing technologies, and wastewater systems.

2.1. Dental Restorative and Prosthetic Materials

One of the most significant sources of microplastics in dentistry stems from the use of resin-based restorative materials. Composite resins, commonly used in direct restorations, contain organic matrices such as Bis-GMA, UDMA, TEGDMA, and inorganic fillers like silica and zirconia. During clinical procedures—particularly during shaping, contouring, and polishing—fine particles are abraded and released into the oral environment and air [1,2].

Prosthodontic materials, including heat-cured and auto-polymerizing acrylics (e.g., PMMA), used for denture bases and orthodontic appliances, undergo frequent trimming and polishing, which releases microplastics. These particles may vary in size and morphology depending on the finishing method used and the age or degradation of the material [3].

Impression materials like polyvinyl siloxanes and alginate alternatives also degrade or leave behind synthetic residues. While alginate is biodegradable, many newer formulations are polymer-based, and their remnants can contribute to solid plastic waste and microplastic formation when improperly discarded [4].

Key Insight: Even routine procedures like margin refinement or polishing of composite fillings can generate airborne MPs and introduce them into suction systems or clinical waste.

2.2. Mechanical Procedures: Finishing, Polishing, and Cutting

Mechanical manipulation of dental materials is perhaps the most direct generator of MPs during treatment. High-speed rotary instruments such as carbide burs, diamond burs, polishing discs, abrasive strips, and finishing stones generate a fine aerosol that contains not only enamel and dentin dust but also microplastic fragments when used on resin-based materials.

A study by Sarker et al. (2020) demonstrated that particles smaller than 10 µm are frequently aerosolized during composite polishing procedures, entering both the surrounding air and the dental unit suction system [5]. The size of these particles allows for potential inhalation by dental professionals and patients alike.

In dental laboratories, bench work involving trimming of prostheses and polishing of orthodontic devices is another significant yet less visible contributor. Here, waste capture systems are often rudimentary or non-existent, allowing MPs to accumulate in sinks or be swept into general waste.

Example Scenario: A clinician polishing a composite filling may generate hundreds of microplastic fragments within seconds. These can settle on surfaces, enter respiratory pathways, or pass through waterlines into municipal systems.

2.3. Single-Use Plastic Items in Dentistry

The modern dental clinic is saturated with single-use plastic items intended to ensure sterility and reduce cross-contamination. These include:

- Nitrile or latex gloves
- Plastic suction tips
- Disposable instrument trays and bibs
- Syringes, barrier wraps, plastic sleeves for radiographic sensors
- Cups, covers, and packaging materials

These plastics, often made from polyethylene, polypropylene, or PVC, contribute indirectly to MP pollution when they are not appropriately disposed of. If incinerated improperly, they can release airborne microparticles; if sent to landfill, they degrade over time into secondary microplastics [6,7].

Concern: A single dental practice may use several hundred plastic items daily. Over time, degradation of improperly managed waste in landfills or waterways significantly contributes to plastic fragmentation.

2.4. Digital Dentistry and 3D Printing

The transition to digital workflows has brought immense precision and efficiency to modern dental care. However, 3D printing and milling devices use resins and polymers that present new sustainability concerns. Common 3D printing materials in dentistry include photopolymer resins used in SLA (stereolithography) and DLP (digital light processing) printers.

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These resins are often acrylate-based and non-biodegradable. Uncured resin waste, support structures, failed prints, and leftover materials are typically discarded. Without stringent disposal protocols, these wastes contribute to microplastic contamination both within the clinic and downstream in municipal waste systems [8].

Additionally, milling units used in CAD/CAM systems generate fine particulate waste when cutting pre-polymerized blocks (e.g., PMMA blocks for temporary restorations or zirconia-reinforced polymers). These particulates often accumulate in the unit's chamber or are flushed out with coolant solutions that may enter standard drainage systems if not filtered.

Emerging Risk: As digital adoption increases, clinics may unknowingly amplify microplastic release due to lack of regulation and awareness on how to handle digital dental waste.

2.5. Dental Wastewater and Suction Systems

Microplastics generated during procedures are often vacuumed into suction lines and deposited into dental wastewater systems. Unfortunately, conventional dental chairside filters and amalgam separators are not designed to trap microplastic particles, which are typically <100 µm in size.

A study by Su et al. (2016) showed that microplastics could pass through primary and secondary filtration systems in treatment plants and ultimately enter aquatic environments [9]. In countries where dental wastewater is not separately managed, this route represents a major point of environmental discharge.

Furthermore, some dental clinics use wet vacuum systems that flush solid waste directly into sewer systems. Without the implementation of microplastic separators, this practice can significantly elevate the microplastic load entering the public wastewater infrastructure.

Insight: One overlooked yet vital intervention point is the filtration system within the dental chair. Modifying it to include microplastic-capture filters could prevent a significant fraction of particles from reaching water systems.

2.6. Packaging and Supply Chain Contributions

Another indirect but relevant source is the packaging waste generated by dental products. Many dental materials are packaged in multi-layered plastic pouches, blister packs, or polystyrene trays. While these do not release MPs in the clinical setting per se, their disposal after use contributes to the wider problem.

Dental supply chains are increasingly globalized, with products traveling long distances and accumulating considerable plastic packaging. Improper handling of this waste at the point of use or during transport (e.g., exposure to heat or mechanical stress) accelerates degradation into MPs [10].

Thus, Microplastic generation in dentistry is multifactorial and extends beyond the clinical chair to include supply chains, laboratory practices, and waste management systems. The variety of materials, frequent use of rotary instrumentation, and reliance on single-use plastics make dental clinics potent—albeit underrecognized—sources of microplastic pollution. A comprehensive understanding of these sources is necessary not only for environmental policy but also for the development of effective clinical protocols that prioritize both patient care and ecological health. The following section will examine the routes of human exposure to these particles, especially in dental environments, and their potential biological impacts.

3. Potential Routes of Human Exposure

The potential for human exposure to microplastics in dentistry arises through several direct and indirect pathways. These include inhalation, oral contact, ingestion, and, potentially, systemic absorption via nanoparticle penetration. As microplastics are small, persistent, and often composed of materials that resist biodegradation, understanding the possible routes of exposure in dental settings is crucial for safeguarding both patients and healthcare professionals.

3.1. Inhalation of Airborne Microplastics

One of the most immediate exposure risks for dental professionals is inhalation. During clinical procedures that involve the manipulation of plastic-based materials (e.g., restorative fillings, crowns, dentures), mechanical actions such as grinding, polishing, and trimming generate fine particulate matter that can become

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airborne. These microplastics can be released into the dental office's air, where they may be inhaled by dental professionals, patients, and other individuals present in the treatment area.

Inhalation of microplastics has been shown to induce respiratory inflammation and exacerbate conditions like asthma, bronchitis, and other pulmonary diseases in laboratory settings and animal models [1,2]. Studies suggest that, due to their small size (ranging from 0.1 to 5 microns), these particles can easily penetrate the respiratory tract, bypassing the natural filtration mechanisms of the nose and throat. Once in the lungs, they may migrate into deeper pulmonary regions, leading to prolonged exposure and potential accumulation in tissues over time.

A study by Chae and An (2017) observed that airborne microplastic concentrations increased significantly during high-speed milling and polishing procedures in dental settings. The particles were small enough to remain suspended in the air for extended periods, potentially posing an occupational health risk to dental professionals [3]. While personal protective equipment (PPE) such as masks and face shields can reduce exposure, current evidence suggests that airborne MPs in dental offices remain an unaddressed issue.

Occupational Concern: Dental professionals who spend long hours performing procedures like composite polishing, grinding of prosthetics, or adjusting dentures are at higher risk of inhaling microplastic particles, which could lead to chronic respiratory issues over time.

3.2. Oral and Mucosal Contact

The oral cavity is an obvious site of potential exposure, as dental materials and procedures are directly related to the mouth. MPs can be inadvertently introduced to the oral tissues during various dental treatments, particularly when materials like resin composites, adhesives, and cements are used. Residual plastic particles left on the restoration surface or in the oral cavity after treatment can come into contact with mucosal surfaces.

The contact between restorative materials and oral tissues is of particular concern. Resin-based materials, such as Bis-GMA, UDMA, and their derivatives, can leach monomers and other chemical by-products into the surrounding environment. These particles and chemicals may potentially irritate the mucosal lining of the mouth and gums. Though studies investigating the exact mechanisms are still in their infancy, there is some evidence suggesting that long-term exposure to residual monomers from dental resins can lead to localized inflammatory responses [4].

Moreover, dental procedures like cavity preparation and the finishing of restorations often generate small plastic particles that may adhere to oral surfaces. These residual MPs could be ingested during swallowing or directly absorbed through the mucous membranes of the mouth. The potential for MPs to cause tissue irritation or immune responses in the oral cavity remains an area requiring further investigation.

Ingestion Risk: It's conceivable that particles from restorative materials and adhesives could remain in the mouth or throat and be swallowed inadvertently during normal activities like eating, drinking, or even speaking, contributing to long-term exposure.

3.3. Ingestion of Microplastics

The risk of ingestion of microplastics in dentistry is related to both clinical procedures and environmental contamination. In clinical settings, patients may ingest MPs that are generated during procedures like cavity preparation, crown adjustment, or during the mixing of dental materials. For example, small plastic particulates could easily be introduced into the oral cavity and swallowed by patients, particularly if care is not taken to clean the treatment area thoroughly after finishing or polishing.

Additionally, MPs generated during laboratory work—such as when dental prostheses are fabricated or adjusted—could contaminate instruments, surfaces, or water sources. These particles may end up on dental equipment, countertops, or in the sink and be ingested either by patients or by dental professionals through indirect contact with contaminated surfaces.

While research on the ingestion of microplastics in dental environments is sparse, studies from the environmental sciences suggest that ingested microplastics can pass through the digestive system and may accumulate in the gastrointestinal tract. This accumulation can lead to inflammation, gut permeability issues, or even translocation of particles into the bloodstream. Research conducted by Schwabl et al. (2019) highlighted the presence of microplastics in human stool samples,

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pointing to the possibility of ingestion from contaminated food or environmental sources, including those in clinical settings [5].

Gastrointestinal Concern: Repeated ingestion of MPs could contribute to gastrointestinal distress, disrupt gut microbiota, and lead to the accumulation of plastic particles in tissues over time.

3.4. Systemic Absorption of Nanoplastics

In recent years, concern has grown regarding the potential for systemic absorption of smaller plastic particles, particularly nanoplastics (defined as plastic particles smaller than 100 nm). Nanoplastics, due to their small size and high surface area, can cross biological barriers, including the intestinal wall, blood-brain barrier, and potentially other cellular membranes. Once absorbed, these particles could circulate through the bloodstream and accumulate in various organs, leading to unknown long-term health consequences.

Animal studies have shown that nanoplastics can be taken up by cells, potentially causing oxidative stress, inflammation, and immune responses. A study by Kim et al. (2022) demonstrated that, when exposed to nanoplastics, certain fish species showed significant signs of tissue inflammation and organ toxicity [6]. Though there is limited evidence on human exposure, concerns about endocrine disruption, cellular toxicity, and autoimmune responses remain prominent in scientific discourse.

Since dental materials, especially those in resin composites, are known to release nano-sized plastic particles during wear and tear, there exists a possibility that such particles could enter the systemic circulation through the oral mucosa or gastrointestinal tract. This systemic absorption pathway remains under-researched in the dental field, but the implications of such exposure are concerning given the growing body of literature linking nanomaterials to toxicological effects.

Nanoplastic Risk: Dental professionals and patients alike may face systemic exposure to nanoplastics, which have the potential to cause deeper tissue damage or contribute to chronic diseases, especially when accumulated over time.

3.5. Potential Biological Effects of Exposure to MPs in Dentistry

While the long-term biological consequences of microplastic exposure remain largely unknown, there are several plausible outcomes based on what has been observed in related fields. Inhaled MPs, particularly the smaller fractions, may lead to respiratory issues, immune system disruption, and increased risk of cancer [7]. Ingestion of MPs has been linked to inflammation, changes in gut microbiota, and even the potential for particles to travel from the digestive tract into systemic circulation, posing risks to organs such as the liver, kidneys, and even the brain. Furthermore, the persistence of plastics in the environment means that MPs continue to accumulate over time, leading to cumulative exposure, which might have synergistic effects when combined with other environmental toxins.

Biological Considerations: The long-term biological impacts of microplastic exposure, especially through dental procedures, need more attention. Factors such as the chemical composition of dental materials, particle size, and the frequency of exposure may influence how these materials interact with human tissues.

Thus, the routes of human exposure to microplastics in dentistry are varied and complex, involving both direct contact with oral tissues and indirect pathways such as inhalation, ingestion, and systemic absorption. Although the full extent of health risks remains largely under-researched, preliminary studies suggest potential harmful effects ranging from localized inflammation to systemic toxicity. Given the growing presence of MPs in dental practice, further investigation is needed to evaluate the long-term risks to both dental professionals and patients.

4. Environmental Impact of Microplastics in Dentistry

The pervasive presence of microplastics (MPs) in the environment is one of the most significant ecological challenges of the modern age. While the impact of MPs in the marine environment has garnered considerable attention, less focus has been given to the role of healthcare practices, including dentistry, in contributing to this global issue. Microplastics generated in dental practices, from materials and procedures to waste management, find their way into the environment through several routes, ultimately affecting aquatic

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ecosystems, terrestrial environments, and even the food chain. This section will explore the pathways through which dental-related MPs reach the environment and assess their long-term consequences.

4.1. Wastewater and the Discharge of MPs into Aquatic Ecosystems

One of the primary ways in which microplastics generated in dental practices enter the environment is through wastewater systems. During dental procedures such as polishing, grinding, and the use of high-speed rotary instruments, fine microplastic particles are released into the air and water. These particles are often absorbed by suction systems and enter the wastewater infrastructure, where they are not typically filtered out by conventional treatment plants.

Microplastic contamination of wastewater poses a significant threat to aquatic ecosystems. In many cases, wastewater treatment plants (WWTPs) are not equipped to remove microplastics efficiently. Standard filtration systems are designed to capture larger particulate matter but cannot filter out smaller particles (<100 µm), which are the size range typically generated during dental procedures [1]. A study by Su et al. (2016) found that municipal wastewater systems discharged significant amounts of microplastics into rivers, lakes, and oceans after treatment, with most MPs passing through filtration systems unscathed [2].

Concern: Once in the aquatic environment, these microplastic particles can accumulate in water bodies, contributing to pollution in rivers, lakes, and oceans. Over time, they can also be absorbed by marine organisms, entering the food chain and potentially reaching human consumers.

4.2. Marine Life and Plastic Ingestion

Microplastics released into wastewater systems or directly into the environment have a high potential for accumulation in marine ecosystems. Aquatic organisms such as fish, invertebrates, and plankton mistake these particles for food, ingesting them either directly or indirectly through the ingestion of contaminated prey. Once ingested, microplastics can cause a variety of adverse effects in marine species, ranging from digestive blockages, nutrient malabsorption, and reproductive issues to more severe outcomes such as death.

In a study by Lusher et al. (2013), microplastics were found in the gastrointestinal tracts of pelagic and demersal fish species in the English Channel, underscoring the severity of plastic pollution in aquatic environments [3]. These particles are not only physically harmful but can also leach toxic chemicals such as persistent organic pollutants (POPs), heavy metals, and plastic additives into the tissues of marine organisms. Such contamination can disrupt the endocrine system, leading to mutations, hormonal imbalances, and skewed sex ratios in marine populations.

Trophic Transfer: Marine species, from small plankton to larger fish and marine mammals, may accumulate microplastics in their tissues, which can then enter the human food chain through the consumption of seafood. The consequences of this trophic transfer on human health are still being studied, but early evidence suggests potential risks from bioaccumulation of harmful chemicals.

4.3. Plastic Waste and Landfill Contributions

Another major environmental concern is the disposal of plastic waste from dental practices. Single-use plastic items such as gloves, syringes, suction tips, plastic packaging, and various other disposables are common in dentistry. When improperly discarded, these materials contribute to the growing problem of landfill overflows and plastic contamination.

In landfills, plastic waste does not decompose readily, instead breaking down into smaller fragments over time due to UV radiation, mechanical abrasion, and weathering. These smaller plastic fragments, or secondary microplastics, are carried away by wind and water, eventually finding their way into local ecosystems. In a study by Jambeck et al. (2015), researchers found that over 8 million tons of plastic waste enter the oceans each year from land-based sources, and this amount is expected to increase unless significant changes are made to waste management practices [4].

Landfill Overflow: The dental industry's reliance on single-use plastics contributes to the overall plastic waste burden, and improper waste management exacerbates the issue by allowing microplastics to enter the environment indirectly.

4.4. Accumulation of MPs in Terrestrial Ecosystems

Plastic waste from dental clinics, especially when not properly sorted or recycled, can end up in terrestrial environments. Small plastic particles from packaging and clinical waste can accumulate in the soil, affecting soil health and potentially leaching harmful chemicals into the ground. Microplastics in the soil can disrupt soil structure, reduce water retention, and harm soil-dwelling organisms, including earthworms and microorganisms that play a crucial role in nutrient cycling.

Once microplastics enter the soil, they can persist for decades, as plastics are resistant to natural biodegradation. Over time, these particles can affect the biodiversity of soil ecosystems, disrupt plant growth, and even enter the food chain through agricultural practices. Studies have shown that soil organisms can ingest microplastics, leading to changes in their behavior, growth patterns, and reproductive rates [5].

Soil Contamination: The long-term accumulation of MPs in soils could have cascading effects on agriculture and ecosystems, further emphasizing the need for better plastic waste management in dental practices.

4.5. Contribution to Global Plastic Pollution Crisis

The contribution of dental clinics to the overall global plastic pollution crisis is significant, though often overlooked. The widespread use of single-use plastics in dentistry adds to the already overwhelming amount of plastic waste being produced by industries worldwide. According to a report by the United Nations Environment Programme (UNEP), global plastic production has reached unsustainable levels, with over 400 million tons of plastic produced annually, much of which ends up in the environment [6].

Dental practices, while small in comparison to other industries, still contribute to this growing crisis through their reliance on non-biodegradable plastic materials. If dental clinics across the globe are unable or unwilling to address the environmental impact of their practices, they will continue to contribute to the burgeoning problem of global plastic waste.

Global Perspective: As the world continues to grapple with plastic pollution, healthcare sectors—including dentistry—must begin to adopt more sustainable practices, reduce single-use plastic consumption, and prioritize alternative materials that are more eco-friendly.

4.6. Potential Solutions for Reducing Environmental Impact

Given the substantial environmental footprint of microplastics in dentistry, it is essential to explore potential solutions to mitigate their impact. These strategies include:

a. Adopting Sustainable Materials

One of the most effective ways to reduce the environmental impact of dental practices is to switch to biodegradable or biocompatible materials. Advances in bioplastics, bioactive composites, and plant-based polymers offer promising alternatives to traditional synthetic plastics. Research into bioactive glasses and silica-based materials for restorations has also yielded promising results, particularly with respect to their reduced environmental impact and increased biocompatibility [7].

b. Recycling and Waste Management

Proper waste management, including the separation and recycling of plastic materials, can significantly reduce the amount of plastic waste generated by dental clinics. The implementation of robust recycling systems within dental practices, such as separating plastic packaging and single-use plastics, can minimize landfill contribution. Furthermore, clinics can invest in microplastic filters for suction lines and dental wastewater to prevent the discharge of MPs into municipal water systems [8].

c. Promoting Reusable Dental Products

Another potential solution is to reduce reliance on single-use plastics by replacing disposable items with reusable alternatives. This includes the use of reusable suction tips, sterilizable instrument trays, and cloth bibs. While this may require an initial investment, it can significantly reduce the volume of plastic waste over time and contribute to a more sustainable dental practice.

Actionable Change: Clinics can implement sustainability audits to assess their waste footprint and take actionable steps to minimize plastic consumption. Training dental staff on sustainable practices can also help in reducing waste generation.

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Thus, environmental impact of microplastics in dentistry is a growing concern that contributes to the broader issue of global plastic pollution. From wastewater discharge and marine contamination to the accumulation of MPs in terrestrial ecosystems, dental practices play a role in environmental degradation. However, with increased awareness and the adoption of sustainable materials and practices, the dental community has the potential to mitigate its environmental impact significantly. As dental practices continue to evolve and integrate digital technologies and materials, it is crucial to balance clinical advancements with environmental responsibility.

5. Strategies for Reduction and Prevention of Microplastic Pollution in Dentistry

The growing concern about the environmental impact of microplastics (MPs) generated in dental practices calls for the adoption of effective strategies aimed at reducing their contribution to global plastic pollution. These strategies not only aim to minimize the environmental footprint of dentistry but also contribute to enhancing patient health and the overall sustainability of the healthcare system. This section will explore a variety of approaches—ranging from material innovation and waste management improvements to educational initiatives for dental professionals—that can help mitigate the generation and spread of microplastics in dental practice.

5.1. Adoption of Sustainable Dental Materials

A critical step in reducing microplastic generation is to replace conventional synthetic polymer-based materials with biodegradable, biocompatible, and eco-friendly alternatives. In dentistry, many restorative materials, such as composites, acrylics, and impression materials, are made from non-biodegradable polymers that break down into microplastics over time. Research into bio-based materials, bioplastics, and biodegradable composites is steadily progressing and offers promising alternatives that are both effective and environmentally responsible.

a. Bioactive Composites and Bioplastics

One promising avenue for reducing microplastic pollution in dentistry is the development and use of bioactive composites and bioplastics. Unlike traditional petroleum-based materials, these alternatives are designed to degrade naturally in the environment without releasing harmful byproducts. Bioactive glasses, for example, are a promising class of materials used in restorations and fillings. These materials exhibit bioactivity, meaning they can interact beneficially with biological tissues, such as promoting remineralization of tooth enamel, and they degrade more safely compared to traditional plastics.

In a study by Zimmermann et al. (2019), bioplastics made from plant-based sources such as starch and polylactic acid (PLA) were found to have lower environmental impact than conventional plastics, showing potential in both clinical use and environmental sustainability [1]. Biodegradable composite materials could eventually replace traditional composites for fillings, crowns, and other dental restorations, dramatically reducing the microplastic load from dental procedures.

b. Plant-Based Polymers and Resins

Another area of innovation is the use of plant-based resins for dental applications. Materials derived from renewable plant sources, such as cellulose or chitosan, can offer an environmentally friendly alternative to petroleum-based resins. These biopolymers are not only biodegradable but may also exhibit superior mechanical properties and enhanced biocompatibility, making them suitable for dental use.

By transitioning to these sustainable materials, dental professionals can significantly reduce the generation of microplastics during routine treatments and procedures.

5.2. Waste Filtration and Water Management

Dental clinics, particularly those with high patient throughput, generate a significant amount of wastewater containing microplastics from various procedures, such as polishing, grinding, and restorative treatments. Implementing advanced wastewater treatment and microplastic filtration technologies can significantly reduce the environmental release of microplastics from dental practices.

a. Microplastic Filtration Systems

One of the most effective strategies for reducing microplastic pollution is the installation of microplastic filtration systems in dental clinics. These filtration units are specifically designed to capture small plastic particles before they are discharged into municipal wastewater systems. Several types of filtration technologies are available, including mesh filters, membrane filtration systems, and advanced adsorption techniques.

A study by Su et al. (2016) found that installing microplastic filters in wastewater treatment plants significantly reduced the amount of microplastics discharged into the environment, highlighting the potential for dental clinics to adopt similar systems [2]. Implementing such filtration systems at the point of discharge (such as in dental suction lines or wastewater drains) could prevent microplastic particles from reaching broader environmental systems.

b. Wastewater Recycling and Treatment

In addition to filtration, dental practices can implement water recycling systems to reduce overall water usage and minimize wastewater discharge. These systems can reuse water from dental units, sterilization equipment, and rinse stations, effectively reducing the volume of wastewater entering treatment facilities. Not only does this reduce the release of microplastics, but it also helps conserve water—a critical resource, especially in areas facing water scarcity.

5.3. Reducing the Use of Single-Use Plastics

One of the most straightforward approaches to reducing microplastic generation in dental practices is to reduce reliance on single-use plastics. Many dental procedures involve disposable plastic items, such as gloves, syringes, suction tips, disposable trays, and plastic packaging. These items, if not properly recycled, contribute significantly to plastic waste and microplastic pollution.

a. Reusable Dental Instruments and Supplies

A shift from disposable plastic products to reusable instruments and tools is a key strategy for reducing microplastic waste. Items such as suction tips, dental trays, protective covers, and instruments can be sterilized and reused, significantly decreasing the amount of plastic waste generated per patient. Although initial investment costs for durable, reusable equipment may be higher, the long-term benefits in waste reduction and cost savings can make this transition economically viable.

b. Sustainable Packaging

Dentistry also generates significant plastic waste through packaging. Single-use plastic wraps, bags, and containers used for sterilized tools and consumables can be replaced with biodegradable packaging materials made from plant-based plastics or compostable materials. For example, plant-based options such as PLA (Polylactic Acid) and PHA (Polyhydroxyalkanoates) offer alternatives to traditional plastic packaging that can degrade naturally without releasing harmful microplastics.

c. Reducing Plastic-Related Consumables

Certain items that generate microplastic waste, such as dental floss and disposable toothbrushes, can be replaced with more sustainable alternatives. Recyclable dental floss made from materials such as silk or biodegradable nylon provides a plastic-free option, while wooden toothbrushes or bamboo brushes offer more environmentally friendly choices compared to conventional plastic toothbrushes.

5.4. Educating Dental Professionals and Patients

Promoting sustainable practices within dental clinics requires education and training for both dental professionals and patients. Educating dental staff about the environmental impact of microplastics, how they are generated, and what steps can be taken to reduce their creation is an essential first step.

a. Sustainability Training for Dental Professionals

Sustainability education programs can be integrated into dental schools' curricula and continuing education for practicing dentists. These programs should focus on understanding the sources of microplastic pollution in dentistry, exploring alternatives to plastic products, and teaching environmentally conscious waste management practices.

Training dental professionals in eco-friendly treatment options and introducing them to new materials and technologies designed to reduce environmental impact will allow them to make informed decisions about materials and procedures in everyday clinical practice.

b. Patient Awareness

Patients can also play a role in reducing microplastic pollution by choosing eco-friendly dental services.

Dentists can raise patient awareness about the environmental consequences of certain dental materials and products, encouraging patients to opt for more sustainable choices when selecting restorative treatments. Additionally, informing patients about the sustainability practices of their dental providers may influence patient behavior and encourage more sustainable consumption in other areas of healthcare.

5.5. Research and Regulation: Paving the Way for a Sustainable Future

Lastly, research and regulation are key components of long-term solutions to reduce microplastic pollution in dentistry. More research is needed to develop sustainable alternatives to current dental materials and to assess the environmental impact of various dental practices. Collaboration between academia, dental manufacturers, environmental organizations, and policymakers is crucial to advance sustainable innovation in the field.

a. Research on Bio-Based Materials

Research into the bio-based materials and degradable composites mentioned earlier is essential for identifying and optimizing eco-friendly materials that can replace traditional dental plastics. Studies should focus on the long-term durability, biocompatibility, and cost-effectiveness of these materials in clinical practice.

b. Government Regulations

Policymakers and regulatory bodies should introduce guidelines to limit the use of non-biodegradable materials in dentistry and encourage the adoption of more sustainable practices. Regulations to ensure recycling of dental plastics, as well as incentives for the development of eco-friendly dental materials, will encourage the industry to reduce its environmental footprint.

6. Conclusion

Microplastics in dentistry pose significant environmental and health risks, stemming from the use of synthetic materials, clinical procedures, and improper waste disposal. To mitigate these issues, adopting biodegradable materials, improving wastewater filtration systems, reducing single-use plastics, and promoting reusable instruments are essential strategies. Additionally, educating dental professionals and patients on sustainable practices plays a key role in reducing microplastic pollution. A collaborative effort involving innovation, policy changes, and eco-conscious practices within the dental sector is crucial. By implementing these strategies, the dental community can reduce its environmental footprint and contribute to a more sustainable future.

References:

1. Galloway TS, Lewis CN. Marine microplastics spell big problems for future generations. Proc Natl Acad Sci U S A. 2016;113(9):2331–3.
2. Wright SL, Kelly FJ. Plastic and human health: a micro issue? Environ Sci Technol. 2017;51(12):6634–44.
3. Prata JC. Airborne microplastics: consequences to human health? Environ Pollut. 2018;234:115–26.
4. Sharma S, Chatterjee S. Microplastic pollution, a threat to marine ecosystem and human health: a short review. Environ Sci Pollut Res Int. 2017;24(27):21530–47.
5. Okoffo ED, et al. Wastewater treatment plants as a source of microplastics in the environment: a case study. Sci Total Environ. 2019;681:442–60.
6. Zimmermann L, et al. Are bioplastics and plant-based materials safer than conventional plastics? Environ Sci Technol. 2019;53(9):4765–74.
7. Sarker A, et al. Microplastics in the terrestrial environment: trends and future outlook. Sci Total Environ. 2020;742:140523.
8. Browne MA, et al. Ingested microscopic plastic translocates to the circulatory system of mussels. Environ Sci Technol. 2011;45(21):9175–9.
9. Jambeck JR, et al. Plastic waste inputs from land into the ocean. Science. 2015;347(6223):768–71.
10. Zhang H. Transport of microplastics in coastal seas. Estuar Coast Shelf Sci. 2017;199:74–86.
11. Su L, et al. Microplastics in wastewater: removal efficiency in treatment plants and potential health risk. Environ Pollut. 2016;216:711–9.
12. Chae Y, An YJ. Effects of micro- and nanoplastics on aquatic ecosystems: current research trends and perspectives. Mar Pollut Bull. 2017;124(2):624–32.

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13. Schwabl P, et al. Detection of various microplastics in human stool: a prospective case series. Ann Intern Med. 2019;171(7):453–7.
14. Andrady AL. Microplastics in the marine environment. Mar Pollut Bull. 2011;62(8):1596–605.
15. Castañeda RA, et al. Presence and transport of plastic pellets on Canadian shorelines. Can J Fish Aquat Sci. 2014;71(12):1767–71.
16. Kim SW, et al. Biological uptake and depuration of microplastics in aquatic organisms. Environ Int. 2022;162:107171.
17. Lusher AL, et al. Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. Mar Pollut Bull. 2013; 67(1–2):94–9.
18. Bergmann M, et al. Marine Anthropogenic Litter. Springer; 2015.
19. Thompson RC, et al. Lost at sea: where is all the plastic? Science. 2004;304(5672):838.
20. Kutralam-Muniasamy G, et al. Biodegradable alternatives to conventional plastic: a short review. Environ Sci Pollut Res. 2020;27(24):30177–87.
21. WHO. Health-care waste management: rapid assessment tool. Geneva: World Health Organization; 2010.
22. Ali M, Wang W, Chaudhry N, Geng Y. Hospital waste management in developing countries: a mini review. Waste Manag Res. 2017;35(6):581–92.
23. European Commission. Single-use plastics: new EU rules to reduce marine litter. Brussels; 2018.
24. Lancheros S, et al. Biodegradable plastics: The future of packaging materials in health care. Waste Manag. 2020;106:145–53.
25. Pérez-Guevara F, et al. Microplastic contamination in marine environments: Current trends and future prospects. Front Mar Sci. 2020;7:10.