

Sustainable Orthodontics - From Innovation to Responsibility

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Abstract: Sustainable orthodontics is an emerging paradigm that integrates environmental, economic, and social considerations into orthodontic practice. As the global healthcare sector contributes significantly to carbon emissions and environmental waste, orthodontics must evolve to reduce its ecological footprint without compromising patient care. This involves adopting eco-friendly materials, minimizing single-use plastics, optimizing digital technologies like 3D printing and virtual treatment planning, and improving energy efficiency in clinical operations. Additionally, sustainable orthodontics promotes ethical sourcing, patient education, and community-based preventive care to reduce the long-term burden of orthodontic treatment. By aligning with the principles of sustainability, the field not only addresses environmental concerns but also enhances resilience and cost-effectiveness in orthodontic service delivery.

Keywords: Orthodontics, sustainability, eco-friendly dentistry.

Introduction

Orthodontists take pride on crafting perfect smiles. However, in the pursuit of aesthetic and functional excellence, we must ask: At what environmental cost? Green dentistry emerges as a methodology aimed at reducing the environmental footprint of dental facilities. This encompasses not just the utilization of sustainable materials and techniques but also entails adopting eco-conscious approaches in waste management, energy preservation, patient care and education initiatives [1]. The carbon footprint of the dental sector which is long overlooked is now a growing concern. From disposable plastics to energy consumption, orthodontic practices contribute significantly to environmental degradation. Fortunately, innovation offers a path toward responsibility.

Digital Dentistry: Less Waste, More Precision

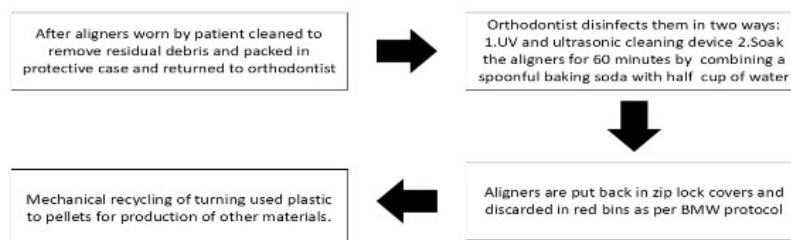
The shift from traditional impressions to intraoral scanning and CAD/CAM systems has dramatically reduced the use of alginate, plaster, and plastic trays-materials that are typically non-recyclable and generate clinical waste [2]. A digital-first approach also enables cloud-based records, minimizing paper use and storage needs. This transition is a cornerstone of modern sustainable practices.

Eco-conscious 3D Printing

3D printing allows for precise appliance production with minimal excess. Labs and clinics using biodegradable or plant-based resins are pioneering a future where sustainability and customization coexist.

The Dark Side of Clear Aligners

While aligners have revolutionized orthodontic care, they've also introduced new sustainability challenges. The average aligner case may use 20–30 plastic trays, each discarded after limited use. Given that most are made of multi-layer thermoplastics, they are neither biodegradable nor easily recyclable. Solutions such as aligner recycling initiatives and research into bio-based polymers (e.g., PLA composites) are emerging [3].

Protocol For Discarding Used Aligners³**Figure 1:** Protocol for Discarding used Aligners [3].**Rethinking Orthodontic Packaging and Consumables**

Single-use plastic packaging commonly seen with brackets, elastics, and aligners—adds significant waste. Suppliers and manufacturers are beginning to offer:

- Recyclable or compostable packaging.
- Reusable bracket trays.
- Eco-friendly sterilization pouches.

Clinicians can encourage procurement from vendors that prioritize green manufacturing and ethical sourcing.

Clinical Waste Management

Hazardous and non-hazardous waste segregation, proper disposal of sharps, amalgam separators, and recycling of dental plastics and metals are critical. Partnering with eco-certified waste disposal services ensures proper treatment of dental waste and limits landfill contamination.

Patient and Staff Involvement**The Four R's: A Framework for Sustainable Practice**

Implementing the principles of Reduce, Reuse, Recycle, and Rethink can guide orthodontic practices towards sustainability. This includes transitioning to paperless records, utilizing energy-efficient equipment, and educating patients on environmentally friendly practices [4].

What is done	Sustainable practice	Benefit
Orthodontic accessories sold in conventional packaging	Brackets sold in receptacles with a larger quantity of accessories, with these receptacles being manufactured of a recyclable product	Elimination of packaging made of plastic materials, being replaced with biodegradable materials
Adhesive systems with acid etching	Self-etching adhesive systems	Lower water consumption due to no need for washing and drying, with same clinical efficacy
Conventional brackets	Self-ligating brackets	Less chair time and eliminates the use of elastomers
Use of non-sterilizable orthodontic archwires	Use of orthodontic archwires capable of being sterilized	Reduce discard of solid residues that may have been contaminated before use in the patient
Re-bond new brackets when they de-bond during treatment	Recycle brackets by roughening their base with aluminum oxide and performing new bonding	Eliminate solid residues that would go to the trash can, making it possible for them to have a longer useful life
Light polymerization with conventional halogen or LED appliances	Ultra-rapid LED light	Shorter chair time and use of LED lamp with low energy consumption
Use of synthetic intermaxillary elastics	Use of elastics made of latex	Latex is extracted from a tree; consequently, there is a need to cultivate trees; therefore, the more widespread the use of latex, the larger the number of trees
The use of a new mini-implant in a patient who needs to replace the one in use	Sterilization and use of the same mini-implant that was removed in the same patient	Reduction of solid residues that are constituents of the mini-implant

Table 1: Alternative and sustainable orthodontic practices and its benefits [5].

Conclusion

Sustainability in orthodontics is not a distant ideal but an urgent necessity. As stewards of oral health, we must extend our responsibility to the environment. Through conscious choices in technology, materials, energy use, and education, we can reshape the future of orthodontic care to be not just effective and innovative, but also ethical and sustainable.

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