

Aligner Wastage: A Review

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Abstract: Clear aligner therapy has become a mainstream orthodontic option because of its aesthetics, comfort, and digital workflow. Alongside these benefits, however, comes a growing environmental concern: aligner wastage. Waste is generated not only from the used aligners themselves, but also from thermoforming offcuts, 3D-printed models, packaging materials, shipping, and refinement stages that require additional trays. This review summarizes the current literature on aligner-related waste, outlines the main sources of material loss across the treatment chain, and discusses emerging strategies to reduce the environmental burden of clear aligner therapy. Current evidence suggests that the scale of plastic waste is substantial, but precise quantification remains limited. Proposed solutions include direct 3D printing of aligners, recycled or bio-based materials, fewer unnecessary refinements, and organized take-back or recycling schemes. More standardized reporting and lifecycle assessment studies are needed to define the true environmental cost of aligner systems and guide sustainable orthodontic practice.

Keywords: clear aligner therapy, orthodontic waste, sustainable dentistry, plastic waste reduction, recyclable aligners

1. Introduction

Clear aligners are now widely used in orthodontics for both adult and adolescent patients because they offer an aesthetic alternative to fixed appliances. Their production relies heavily on digital planning, model fabrication, thermoforming, trimming, packaging, and transport. While this workflow is clinically efficient, it is also materially intensive.

Unlike traditional orthodontic appliances, which are adjusted over time, aligner therapy often requires a **series of multiple plastic trays**, sometimes extending to dozens of sets per patient. Additional “refinement” stages may further increase consumption. As concern about healthcare sustainability grows, the environmental impact of aligner therapy has become an important topic in orthodontic literature. Recent commentary and review papers increasingly note that the popularity of aligners is contributing to a **significant plastic waste stream**.

Sources of Wastage in Clear Aligner Therapy

Wastage in aligner therapy occurs at several stages:

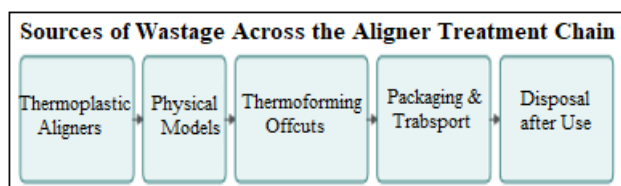


Figure 1: Sources of wastage across the aligner treatment chain

1) Thermoplastic aligners themselves

Each treatment consists of a sequence of removable trays made from **thermoplastic polymers**. Depending on treatment complexity, patients may receive many aligners per arch, and some manufacturers offer extensive or effectively unlimited refinement phases. This means the final number of trays used can be much higher than initially planned.

2) Physical model waste

In conventional production, each aligner is commonly fabricated by **thermoforming plastic over a printed model**. This creates a second waste stream: the discarded study models. A recent sustainability review notes that the amount

of plastic generated by these physical models is still **largely unknown**, despite their routine use.

3) Thermoforming offcuts and failed production

The thermoforming process also produces **excess material** that must be trimmed away. If an aligner is defective, poorly fitting, or clinically replaced, additional plastic is consumed. This hidden manufacturing waste is rarely visible to patients but contributes to the total footprint.

4) Packaging and transportation waste

Aligners are usually delivered in **individual pouches, boxes, sleeves, and shipping materials**. When trays are manufactured centrally and transported repeatedly during treatment and refinements, packaging waste and transport emissions increase further.

5) Disposal after use

Used aligners are often discarded into **general household waste**. Because these materials have been in the oral cavity, they may not enter routine municipal recycling streams. Several authors have highlighted the lack of clear disposal pathways and consistent patient guidance.

2. Scale of the Problem

The **exact global magnitude** of aligner waste is still uncertain, but existing publications suggest it is substantial. A 2024 letter discussing environmental impact estimated that treatment for an average individual involves the production of **640 cm² of thermoplastic**, excluding residual production waste, and argued that this creates a meaningful global plastic waste cycle when multiplied across millions of patients.

A British Dental Journal letter also pointed out that some patients may receive **up to 40 sets** of upper and lower aligners per course of treatment, with further trays added if tooth movement does not proceed as predicted.

At the same time, the literature repeatedly emphasizes a core limitation: **robust quantitative lifecycle data are sparse**. Most current publications are letters, commentaries, or narrative reviews rather than full environmental lifecycle assessments.

Environmental and Clinical Implications

The key concern is that aligner therapy depends on **petroleum-based plastics** that are not easily reintegrated into a circular reuse system. In addition to plastic accumulation, the process consumes energy through scanning, printing, thermoforming, finishing, and shipping.

This issue does not mean aligners should be abandoned clinically. Rather, it suggests that orthodontics should evaluate whether digital convenience is being achieved at an **unnecessary environmental cost**. Treatment planning that reduces avoidable refinements, improved fit prediction, and more selective production schedules may help lower waste without compromising care.

Strategies to Reduce Aligner Wastage

Several strategies are being discussed in the literature:

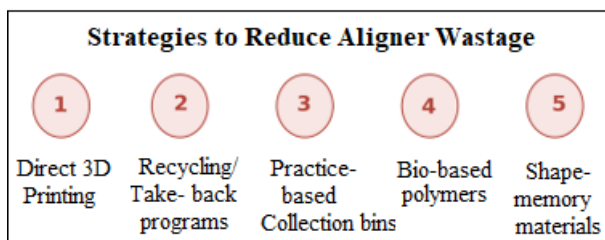


Figure 2: Proposed strategies to reduce aligner-related waste.

- **Direct 3D printing of aligners** could eliminate the need for intermediate printed models and reduce waste from thermoforming workflows. However, currently available materials remain limited and must satisfy biocompatibility, optical, and mechanical requirements.
- **Recycling programs** are beginning to appear. TerraCycle, for example, accepts used dental aligners, cases, and flexible aligner packaging through a dedicated collection program.
- **Practice-based collection bins** have been proposed so patients can return used aligners instead of discarding them with household waste.
- **Bio-based or alternative polymers** may offer future sustainability gains, although current evidence is still emerging and practical adoption remains limited.
- **Shape-memory materials** may reduce the number of trays needed by allowing a single appliance to perform multiple programmed stages of movement. This remains a promising but developing area.

3. Conclusion

Aligner wastage is an emerging environmental issue within modern orthodontics. The waste burden extends beyond used trays to include printed models, production offcuts, packaging, and repeated refinement cycles. Although the current evidence base is still developing, the direction is clear: clear aligner therapy produces a nontrivial plastic footprint that deserves systematic attention. Future research should prioritize lifecycle assessment, standardized waste reporting, and clinical innovations that reduce material use while preserving treatment quality. Sustainable orthodontics will likely depend on combining smarter manufacturing, better disposal systems, and more efficient treatment planning.

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