International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html



# An Overview on Environmental Hazards of Clear Aligners

*Rasiga Gandhi* and Anuradha Veerasekaran*

*Department of Orthodontics, SRM Dental College, Ramapuram, Chennai, India-600089*

**Abstract**

This article aims to review the currently available disposal method of clear aligners and create awareness on the environmental hazards they can possess. Thermoplastic aligners have emerged as the most popular and adaptable orthodontic treatment option in this constantly changing environment with an increase in demand for aesthetics. However, as the use of thermoplastic aligners has increased, there has been a steady growth of non-biodegradable plastic trash with each passing year, which in turn is contributing to global warming and is also unpleasant to the environment. The material properties of aligners and the currently followed disposal method have been reviewed and discussed. It is the responsibility of orthodontists and dentists to raise the issue and endeavor to reduce plastic waste in order to prevent environmental problems. This is significant because existing popularity for clear aligner treatment in turn increases the plastic waste turnover and awareness on correct disposal methods is the need of the hour.

**Keywords:** Clear Aligners, Orthodontic Treatment, Biomedical Waste, Thermoplastic, Disposal, Environmental Hazards

**Mini review article** **Corresponding Author*, e-mail: *rasigagandhi@gmail.com*

## 1. Introduction

Orthodontic patients site esthetics as the major concern and unaesthetic braces do not seem to be the correct solution for many [1]. The need for aesthetic solution evolved since emergence of orthodontics as dental specialty in the early 1900s where metal bands were placed around teeth and later moved to bondable metal brackets in the 20$^{th}$ century. Appliance further became even less conspicuous with development of tooth colored brackets including plastic brackets, polycrystalline ceramic brackets, esthetic arch wires that consist of ceramic wires, optiflex wires, teflon coated wires, epoxy coated wires, plastic coated wires, bioforce wires, lingual orthodontics and finally clear plastic aligners [2,3]. This incredible technical advancement heralded a revolution. Patients' desires for orthodontic treatment that is more aesthetically pleasing, comfortable, and inconspicuous were the main motivators behind this novel discovery. The first aligners in orthodontic practice debuted toward the end of the previous century in 1999 and it made substantial progress with advancing computer technologies and have been gaining popularity over the last decade in an attempt to improve occlusion and alignment along with esthetics [4]. A paradigm shift in orthodontics brought about by the introduction of aligners has encouraged people of all ages to receive treatment for the malocclusion, even the elderly. The number of patients undergoing orthodontic treatment with them is gradually rising. Hence, one must also take into account the biomedical waste produced by aligners, which would significantly increase given the exponential rise in their use. As they are constructed of non-biodegradable plastics, discarded aligners can be extremely harmful to the environment [5]. These polymers have the potential to endanger our ecosystem and can take millennia to degrade [6]. Therefore, proper care must be taken when disposing of aligners. The aim of the article is to discuss the material properties of aligners, to review the currently followed disposal method and to create awareness on disposal methods.

## 2. History and evolution of aligners

The concept of clear aligner treatment is not new to orthodontics and is a modern adaptation of the systems described since the middle of 20th century. It therefore seems necessary to briefly describe devices and philosophies that led to its creation and how the system has evolved over the decades.

1925-Orrin Remensnyder's introduction of the gum massaging device 'Flex-O-Tite' where he observed a surprising side effect to this treatment where certain teeth were found to have moved marginally served as the catalyst for the concept [7].

1945- Kesling developed the idea of using a series of rubber-based teeth aligners made out of ebonite gum to gradually realign malaligned teeth to better positions without bands and wires [8].

1964- The first clear thermoplastic appliance that could shift teeth into an orthodontic position was introduced by Nahoum called the "dental contour appliance" [9].

1971- Ponitz created an "Invisible Retainer" that could result in minute tooth movements by tipping crowns. He described the thermoforming process of the invisible retainer using

Polymethylmethacrylate, known as Biocryl and its applications [10].

1985- McNamara took up the idea of Ponitz, considered that the invisible retainer can be used at the end of orthodontic treatment or as a transitional retainer between certain stages of treatment. In vacuum thermoforming, McNamara preferred the system biostar which used pressure rather than aspiration [11].

1990- In France, Amoric presented many applications of the thermoformed appliance like monoblocs, Herbst mandibular advancement splints, finishing retainers [12].

1993- Sheridan developed the "Essix system" which was in fact an acronym to describe his esthetic solution for correcting the six anterior teeth (the social six). He used its trays only for the purpose of retention or at best the dental movements that he carried out were "minors tooth movements". He described a method that combined interproximal tooth reduction with clear polypropelene trays [13].

1997- Two MBA graduate students, Zia Chishti and Kelsey Wirth at Stanford university applied three- dimensional (3D) computer imaging graphics to the field of orthodontics and created the invisible aligner system [4].

1999- This treatment was taken into the lab using Align technology (Santa Clara, California) which launched Invisalign enabling doctors to outsource it. It was the first orthodontic appliance to be produced using computer-aided design and computer-aided manufacturing (CAD-CAM). This technique eliminated the need for separate impressions for each tooth movement and enabled the creation of several movements from a single impression or scan.

## 3. The materials used in clear aligners and their properties

The ideal properties that a clear aligner must possess include,

- *Adaptability*- A key criterion for an aligner material is its capacity to adjust or conform to the models throughout the thermoforming process.
- *Dimensional stability*- To achieve the intended tooth movement in a clear aligner, the material must be stiff enough to produce the loads and moments needed. The aligner material should be dimensionally stable in the oral environment and since the material is viscoelastic, the force produced by the appliance diminishes over time. The elastic properties of the aligners are more significantly impacted by the type and thickness of the material used in manufacture [14].
- *Transparency*- Aligner materials should and should have high light transmission of up to 80% of visible light. Amorphous polymer materials that exhibit good optical properties are suitable for aligner fabrication than crystalline materials which are opaque and unaesthetic.
- *Colour stability*- Pigment adsorption from food and drinks in the oral cavity should be minimal to null.
- *Breakdown* - Saliva is continuously in contact with aligners at a constant body temperature, which can negatively impact the chemical makeup of polymers. The polymer that is utilized to make aligners should withstand hydrolysis and water breakdown.[15]
- *Stress resistance*- An aligner material's ability to withstand surface cracking under cyclic stress in the oral environment is crucial.
- *Wear resistance and durability*- The is constant masticatory force on the aligners and they should be resistant to facture and durable.
- *Surface roughness*- Retention over a tooth's surface and tooth movement can be affected by deterioration of roughness characteristics and mechanical qualities while using an aligner over weeks [15].
- *Biocompatibility*- The polymers shouldn't release any toxins that could have detrimental local or systemic effects.

The aligners' effectiveness can vary depending on their thickness, mechanical characteristics and consequently, their functionality. Thermoplastic materials like Polyethylene Terephthalate Glycol (PET G), polyurethane, poly vinyl chloride (PVC) etc., possess the required properties and are used for fabrication of clear aligners by aligner producers [16]. There are more than 27 products available, different companies use different materials. For example, align has formulated a patented material for the manufacture of trays. Polyurethane is the most commonly used aligner material with superior material adaptation compared to other materials [17]. It is an amorphous polymer with well-defined glass transition temperature with adequate mechanical and optical characteristics required for an aligner material. Polyester, PVC, poly sulfone and polycarbonate are also some of the polymer materials that exhibit good optical properties suitable for aligner fabrication. Higher resistance to fracture in environmental stress is seen in polyurethane and polycarbonate when compared to other polymers. However, polyurethane aligner material is more prone to staining by pigment adsorption from food and drinks in the oral cavity [18]. PETG is a light, optically superior material resistant to wear, with sufficient elasticity that allows gradual tooth movement. PVC is a material with elastic characteristics following a plastic deformation when exposed to moderate loads and this characteristic could allow reducing the wear time per day.

## 4. Patient related problems with aligner materials

Because they are designed to snugly fit the entire dentition, clear aligners occasionally irritate the oral mucosa. Under the transparent aligners, plaque and saliva can build up and encourage the growth of Porphyromonas gingivalis, leading to a variety of periodontal issues. Periodontal care should be directed towards eliminating the bacterial infection and preventing reinfection and elimination of as many plaque-retentive areas [19]. The aligners can be easily removed and are changed frequently, thus ensuring better oral hygiene. Another issue brought on by transparent aligners is dry mouth, lip swelling, headache, and hypersensitive response to clear aligners (anaphylaxis). Allergic reactions to aligners is rare but can occur in patients allergic to plastic. There have been concerns about release of an artificial compound known as bisphenol-A (BPA) which is known to interfere with endocrine function and to have negligible estrogenic effects. Lack of a considerable release of BPA with clear aligners has been validated by numerous studies. An in vitro investigation was carried out by S Katras et al. to determine how much BPA was released from 4 different kinds of aligners. The variations in BPA content were not statistically significant. They discovered that the majority of BPA was released within the first day use [20]. Patients can

be asked to soak or rinse the aligners prior to use to avoid exposure. Individual responses to aligners vary from patient to patient, tooth to tooth and one tooth movement to another and sometimes non-tracking of tooth movement might occur. Therefore, patients should make sure that each aligner is completely passive before progressing to the next aligner. The optimum wear of each clear aligner appliance is 2 weeks approximately for 16 to 20 hours per day [21]. Wherein a slightly modified protocol of 22 hours a day for one week is also being recommended now a day [22].

## 5. Environmental hazards of aligners

Given the rising popularity and demand for clear aligner treatments and the frequency of change of aligner every week, we need to consider the environmental dangers that discarded aligners can cause. Since plastic can take up to 100 years to decompose in landfills, as we all know, aligners are constructed of this material that are not biodegradable, particularly Polyethylene Terephthalate, which has a high level of resistance to deterioration. Every year, over 25 million aligner trays are thought to be thrown away in landfills worldwide, harming our environment greatly.

## 6. Current strategies followed for aligner disposal

After the patients uses them, they are frequently dumped in regular trash, which may lead to the spread of infection because they were worn in the oral cavity. Because of this issue, clear aligners are categorized as Contaminated Bio Medical Waste in some countries like USA and this makes them unfit for routine primary recycling. The burning of plastic trash in incinerators may cause the release of hazardous chemicals and gases seriously harming the environment [23]. In addition, when harmful chemicals from burning, such as polychlorinated biphenyls and dioxins, are released into the atmosphere, they endanger all living beings. The role of the Orthodontist comes into play here by raising awareness among the patients about difference of aligners from regular plastic waste and safe practice of disposal. All patients must be encouraged to gather and bring any used aligners to their orthodontist at the end of treatment. Proper sterilization and disposal according to biomedical waste segregation of orthodontic aligners in a red medical waste bag should be carried out [24]. These days, a lot of businesses focus on recycling clear aligners because they contain a variety of plastic structures and so require a unique recycling technique. There are specific bags and tiny boxes that can be used to keep worn aligners until they are sterilized and recycled. Mechanical or secondary recycling are the only realistic and safest ways for the appropriate treatment of aligners. This process turns the discarded aligner material into granules, which are then used to make different materials as the basic mechanical properties are lost [23].

## 7. Conclusions

There is a need for standard clear aligner usage and disposal recommendations to be followed by the orthodontists and the patients. The benefits and drawbacks of transparent aligners should be highlighted so that we can achieve greater treatment goals along with environment friendly waste management practices. Proper coordination between dentists and recycling or manufacturing industries can aid in successful recycling of aligners.

## References


[1] B. Mani. (2021). A Study on Patient's Expectations and Perception of Orthodontic Treatment according to Different Age Group. Annals of RSCB. 25(6): 16062–6.

[2] D. Patel, F. Mehta, N. Mehta. (2014). Aesthetic orthodontics: an overview. Orthodontic Journal of Nepal. 4(2): 38–43.

[3] S. Kaur, R. Singh, S. Soni, V. Garg, M. Kaur. (2018). Esthetic orthodontic appliances-A review. Annals of Geriatric Education and Medical Sciences. 5(1): 11–4.

[4] F. Mehta, S. Mehta. (2014). Aligners: The rapidly growing trend in orthodontics around the world. Indian Journal of Basic and Applied Medical Research. 3(4): 402–9.

[5] C.S. Li, F.T. Jenq. (1993). Physical and chemical composition of hospital waste. Infection Control and Hospital Epidemiology. 14(3): 145–50.

[6] M.P.M. Freitas. (2022). Aligners, Environmental Contamination, and The Role of Orthodontics. Angle Orthodontist. 92(1): 148.

[7] O. Remensnyder. (1926). Appliance in the treatment of pyorrhea. Dental Cosmos. 28: 381-4.

[8] H.D. Kesling. (1945). The philosophy of the tooth positioning appliance. American Journal of Orthodontics and Oral Surgery. 31(6): 297–304.

[9] H.I. Nahoum. (1964). The vacuum formed dental contour appliance. NewYork State Dental Journal. 9: 385–90.

[10] P.J. Ponitz. (1971). Invisible retainers. American Journal of Orthodontics. 59(3): 266–72.

[11] J.A. McNamara. (1985). In-visible retainers. Journal of Clinical Orthodontics. 19: 570–8.

[12] M. Amoric. (1990). Thermoformed orthodontic appliances. Journal of Clinical Orthodontics. 24(6): 351–9.

[13] J.J. Sheridan. (1993). Essix retainers: fabrication and supervision for permanent retention. Journal of Clinical Orthodontics. 27: 37–45.

[14] L. Lombardo, E. Martines, V. Mazzanti, A. Arreghini, F. Mollica. (2016). Siciliani G. Stress relaxation properties of four orthodontic aligner materials: a 24-hour in vitro study. Angle Orthodontics. 87(1): 11–8.

[15] D. Fang, N. Zhang, H. Chen, Y, Bai. (2013). Dynamic stress relaxation of orthodontic thermoplastic materials in a simulated oral environment. Dental Materials Journal. 32(6): 946–51.

[16] N. Zhang, Y. Bai, X. Ding, Y. Zhang. (2011). Preparation and characterization of thermoplastic materials for invisible orthodontics. Dental Materials Journal. 30(6): 954–9.

[17] N.D. Kravitz, B. Kusnoto, E. BeGole, A. Obrez, B. Agran. (2009). How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. American Journal of Orthodontics and Dentofacial Orthopedics.135(1): 27-35.

[18] C.L. Liu, W.T. Sun, W. Liao, W.X. Lu, Q.W. Li, Y. Jeong, Z.H. Zhao. (2016). Colour stabilities of three

types of orthodontic clear aligners exposed to staining agents. International Journal of Oral Science. 8(4): 246-253.

[19] S. Kishore, V. Barai, S. Siva, K. Venkatesan. (2022). Orthodontic-Periodontics: An Interdisciplinary Approach. Periodontology - Fundamentals and Clinical Features.

[20] S. Katras, D. Ma, A. al Dayeh, D. Tipton. (2021). Bisphenol A release from orthodontic clear aligners: an in-vitro study. Recent Progress in Materials. 3(3): 1–13.

[21] A.M. Bollen, G. Huang, G. King, P. Hujoel, T. Ma. (2003). Activation time and material stiffness of sequential removable orthodontic appliances. Part 1: ability to complete treatment. American Journal of Orthodontics and Dentofacial Orthopedics. 124(5): 496–501.

[22] M. Al-Nadawi, N.D. Kravitz, I. Hansa, L. Makki, D.J. Ferguson, N.R. Vaid. (2020). Effect of clear aligner wear protocol on the efficacy of tooth movement: A randomized clinical trial. Angle Orthodontics. 91(2): 157–63.

[23] B. Joseph, J. James, N, Kalarikkal, S. Thomas. (2021). Recycling of medical plastics. Advanced Industrial and Engineering Polymer Research. 4(3): 199–208.

[24] S. Shukla, T. Chugh, R. Ahluwalia. (2022). Biomedical waste segregation in orthodontics after COVID. Santosh University Journal of Health Sciences. 8(1): 62.