AMERICAN JOURNAL OF BIOLOGY AND NATURAL SCIENCES
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

Article

Fabrication of Aligners Using Digital Technologies in Orthodontics

Rustamov Elshan Anvar[1], Mehmani Vusala Rasim[2], Ashrafov Davud Sergey[3]

1. Doctor of Philosophy in Medicine, Assistant
2. Department of Orthodontics, Assistant
3. Department of Orthopedic Dentistry, Assistant Azerbaijan Medical University Baku, Azerbaijan

Citation: Anvar, R. E, Rasim, M. V & Sergey, A. D. Fabrication of Aligners Using Digital Technologies in Orthodontics. American Journal of Biology and Natural Sciences 2054, 2(11), 63-65.

Received: 10th Okt 2025
Revised: 25th Okt 2025
Accepted: 04th Nov 2025
Published: 13th Nov 2025

Abstract: Modern orthodontics has developed a comfortable and effective method for correcting malocclusion using aligners, which are completely invisible on the teeth and cause no discomfort to the patient. Aligners are made from a special type of thermoplastic material. During use, they exert a gentle yet continuous pressure on the teeth, gradually moving them along a predetermined trajectory toward the desired position. Over the past decade, removable orthodontic thermoplastic appliances — aligners — have become a popular alternative to conventional fixed systems and orthodontic devices designed to correct malocclusion by applying forces that induce controlled tooth movement. The technology for designing and fabricating aligners makes it possible to develop an individual alignment system with full control over thickness, coverage, and attachment elements.

Keywords: Aligner, Bracket System, Orthodontic Appliances, Orthodontics, 3D Printing

Introduction

In the past decade, removable orthodontic thermoplastic aligners have become a widely used alternative to conventional fixed systems [1], as well as to other orthodontic appliances designed to correct malocclusion by generating forces that cause controlled tooth movement.

Traditionally, fixed appliances—consisting of metal archwires and brackets—have been used in clinical orthodontic practice. Recently, however, due to the growing demand for minimally invasive alternatives, biomedical research has focused on developing devices that combine **high efficiency in tooth alignment** with improved **comfort and aesthetics** [2].

In modern orthodontics, specialists increasingly prefer to use aligners instead of traditional bracket systems for occlusal correction. This preference is based on the unique advantages of aligners:

1. they are **removable**, making **oral hygiene** significantly easier;
2. they are **custom-made** according to the individual anatomical parameters of each patient's jaw;
3. their **transparency and discreteness** substantially improve psychological comfort.

This practice is becoming more widespread and helps address the needs of a large number of patients who present with various temporomandibular joint (TMJ) dysfunctions, which are often related to the joint's complex structure and function. Approximately one-third of patients with

orthodontic issues require specialized treatment, including the use of specific orthodontic devices for correction [3].

Thus, orthodontic aligners represent a highly aesthetic and functional alternative to conventional fixed orthodontic appliances, making them particularly popular among adult **patients** [4].

Materials and Methods

This review article presents findings from international studies on removable orthodontic appliances used for the correction, prevention, and treatment of dentoalveolar anomalies. The **aim of the review** is to examine the methods and approaches to modeling removable orthodontic appliances — aligners, as well as to analyze the technologies used in their fabrication.

Orthodontics is currently approaching its fourth stage of development since its emergence as a dental specialty in the early 1900s. At that time, malocclusions were treated using metal bands, which were cemented to the teeth to secure wires that applied corrective forces.

By the **1970s**, the orthodontic field welcomed the introduction of standardized brackets made from transparent or semi-transparent non-metallic materials, marking a major milestone in orthodontic progress. This advancement followed the revolutionary **introduction of stainless-steel bracket systems in the 1960s**, which transformed the field by providing a combination of high strength, durability, reduced friction between components, improved saliva drainage, decreased food debris accumulation, and ease of fabrication and adjustment [5].

The first transparent brackets, made of unfilled polycarbonate, were later replaced with ceramic, fiberglass-, or polycarbonate-reinforced brackets featuring metal inserts to minimize material creep [6]. Subsequently, ceramic brackets (made from monocrystalline sapphire or polycrystalline ceramics) became common, but their hardness sometimes led to enamel wear.

Results and Discussion

As a result, orthodontics began transitioning from traditional steel archwires to **advanced materials** such as Optiflex (with transparent fibers) and various types of wires with specialized coatings — including Teflon, epoxy resin, titanium plastic, and Bioforce alloys [7].

In **recent decades**, particularly from the late 20th to the early 21st century, the field has seen the **emergence of aligners** in orthodontic treatment. This innovation is considered a key milestone in the evolution of modern orthodontic science, marking the beginning of a new era that many researchers refer to as the third orthodontic revolution [8].

Aligners, designed as transparent removable trays, are aimed at correcting various irregularities in the position of individual teeth, as well as in the entire dental arch and bite, once the latter has become permanent. These devices are **engineered to apply controlled pressure** to the teeth, gradually aligning them and correcting malocclusions [9].

Clear aligners are custom-made removable orthodontic appliances designed for comprehensive cosmetic treatment of **mild to moderate malocclusions** [8]. The system enables **gradual tooth movement** through a sequence of aligner sets, which are worn and replaced at specific intervals throughout the course of treatment [3].

In the study by **S. Barone et al.**, a patient-specific system was developed to simulate orthodontic tooth movement using plastic aligners. The **upper and lower dental arches** were reconstructed using a combination of optical and radiographic techniques, after which a **finite element (FE) model** was created to analyze two different aligner configurations. The authors evaluated the effect of non-uniform aligner thickness **and** individual initial misfit between the aligner and the patient's teeth [10].

In **1998**, the **Align Technology** company (USA) introduced the **Invisalign system**, consisting of transparent orthodontic trays. Unlike traditional braces, these devices can be **removed during meals or oral hygiene routines**, making them particularly appealing due to their aesthetic advantages. The trays are worn on the teeth and achieve correction without any additional attachments, requiring continuous daily wear with occasional breaks [9].

Geometric fit and material properties are key factors influencing aligner effectiveness, both of which depend on the choice of material and manufacturing method [7]. As noted by R.L. Boyd et al., since its introduction in **1999**, the system of tooth correction using **semi-transparent thermoplastic**

aligners, fabricated through computer scanning and visualization technologies, has become a widely accepted treatment method [8].

The main advantages of aligners include:

1. Invisibility during wear, making them highly aesthetic;
2. Ease of oral hygiene**,** as they can be easily removed and reinserted;
3. Safety for the oral mucosa and enamel, due to the absence of hard metallic or ceramic components, replaced by soft, biocompatible materials**;**
4. Quick adaptation **and** absence of foreign-body sensation in the oral cavity [3].

However, **d**isadvantages include their **limited functional scope** — aligners cannot be used to treat patients with severe malocclusions (such as **tremas or diastemas**) — as well as their high cost [11]. Despite the development of **new materials and auxiliary components** for aligner-based orthodontics, the majority of aligners are still produced using thermoforming technology [5].

Conclusion

The modern method of treating malocclusion using aligners not only ensures effective correction of dental irregularities but also provides a comfortable orthodontic experience for the patient. This review examined the materials used in aligner fabrication, as well as the modeling methods and manufacturing technologies involved.

Although aligners have certain limitations, including restricted indications for use and **high cost**, they hold great promise for the future due to their simplicity, practicality, and patient comfort.

REFERENCES

[1] T. M. Graber, R. L. Vanarsdall, and K. W. L. Vig, *Orthodontics: Current Principles and Techniques*, 6th ed. Elsevier, 2020.

[2] A. A. Solovyov, "Modern aspects of orthodontic treatment using brackets and aligners," *Russian Dental Journal*, 2022.

[3] S. Barone, A. Paoli, A. V. Razionale, and R. Savignano, "Modelling strategies for the advanced design of polymeric orthodontic aligners," in *Biomedical Engineering Systems and Technologies (BIOSTEC 2016), Communications in Computer and Information Science*, F. A. Fred and H. Gamboa, Eds. Springer, 2016. doi: 10.1007/978-3-319-54717-6_5.

[4] I. A. Degtev, S. V. Kazumyan, F. A. Bilalova, *et al.*, "Materials for aligner thermoforming," *International Research Journal*, vol. 4, no. 2, 2021. doi: 10.23670/IRJ.2021.106.4.048.

[5] R. L. Boyd, R. J. Miller, and V. Vlaskalic, "The Invisalign system in adult orthodontics: Mild crowding and space closure cases," *Journal of Clinical Orthodontics*, vol. 34, pp. 203–212, 2000.

[6] M. Upadhyay and S. A. Arqub, "Biomechanics of clear aligners: Hidden truths & first principles," *Journal of the World Federation of Orthodontists*, vol. 11, no. 1, pp. 12–21, 2022.

[7] S. Barone, A. Paoli, A. V. Razionale, and R. Savignano, "Computational design and engineering of polymeric orthodontic aligners," *International Journal for Numerical Methods in Biomedical Engineering*, vol. 33, no. 8, e2839, 2017. doi: 10.1002/cnm.2839.

[8] M. D. Rosvall, H. W. Fields, J. Ziuchkovski, *et al.*, "Attractiveness, acceptability, and value of orthodontic appliances," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 135, no. 3, pp. 276–277, 2009. doi: 10.1016/j.ajodo.2008.09.02.

[9] S. Zinelis, T. Eliades, G. Eliades, *et al.*, "Comparative assessment of the roughness, hardness, and wear resistance of aesthetic bracket materials," *Dental Materials*, vol. 21, pp. 890–894, 2005. doi: 10.1016/j.dental.2005.03.007.

[10] R. J. Dobrin, I. L. Kamel, and D. R. Musich, "Load-deformation characteristics of polycarbonate orthodontic brackets," *American Journal of Orthodontics*, vol. 67, pp. 24–33, 1975. doi: 10.1016/0002-9416(75)90126-8.

[11] S. Kaur, R. Singh, and S. Soni, "Esthetic orthodontic appliances — A review," *Annals of Geriatric Education and Medical Sciences*, vol. 5, pp. 11–14, 2008.