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Aligners: General Characteristics, Advantages, and Disadvantages (Review)

▷ **Abstract.** In the past decade, removable orthodontic thermoplastic appliances—aligners—have become a widespread alternative to traditional fixed systems and orthodontic devices designed to correct malocclusion by applying forces that induce specific tooth movements. The technology used in the production and application of aligners enables the development of a customized alignment system with complete control over desired thickness, coverage, and attachments.

The purpose of the review is to examine the methods and options for modeling removable orthodontic appliances—aligners—and to analyze the technologies used to produce them.

Results. The main advantages of using aligners are their invisibility during wear, which makes them aesthetically very attractive, and the ease of self-maintenance of oral hygiene. Also, aligners protect the oral mucosa and eliminate the risk of enamel damage, as they contain no hard metal or ceramic components. Instead, they use soft, biocompatible material locks. Ease of adaptation and the absence of a foreign body sensation in the mouth also distinguish aligners from other methods of dental correction. The disadvantages of aligners include their limited functionality, since they cannot be used to treat patients with severe occlusion (for example, in cases of large diastemas or gaps between the teeth), as well as their relatively high cost.

Conclusion. The modern method of treating malocclusion with aligners allows for correcting dental disorders and providing comfortable orthodontic treatment for the patient. Aligners have excellent prospects for the future due to their simplicity, practicality, and patient convenience.

Keywords: *aligner, bracket system, orthodontic constructions, orthodontics, 3D printing.*

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Introduction

In the past decade, removable orthodontic thermoplastic aligners have become a common alternative to traditional fixed systems [1] and orthodontic appliances designed to correct malocclusion by applying forces that produce specific tooth movements. Traditionally, clinical practice has relied on fixed appliances, such as metal arches and brackets. Recently, driven by the demand for minimally invasive alternatives, biomedical research has focused on developing devices that combine the effectiveness of tooth movement correction with comfort and aesthetics [2].

In modern orthodontics, specialists increasingly prefer aligners over traditional bracket systems for bite correction. This preference is based on the

unique advantages of aligners: they are removable, making them easy to take off, which significantly simplifies oral hygiene; they are custom-made according to the individual parameters of each patient's jaw; and because of their discreteness, they significantly improve psychological comfort.

This practice is becoming increasingly widespread and allows addressing the problems of numerous patients diagnosed with various temporomandibular joint dysfunctions, which are caused by the complex structure and functionality of the temporomandibular joint. At the same time, about one-third of patients with orthodontic problems require specialized care, including the use of specific orthodontic devices for correction [3].

Thus, orthodontic aligners represent a highly aesthetic alternative to fixed orthodontic appliances,

making them extremely popular, especially among adults [4]. This review article presents the findings of foreign researchers on removable orthodontic appliances used for the correction, prevention, and treatment of dentoalveolar anomalies.

The purpose of the review is to examine the methods and options for modeling removable orthodontic appliances—aligners—and to analyze the technologies used to produce them.

Orthodontics is currently approaching its fourth stage of development since emerging as a distinct dental specialty in the early 1900s. At that time, malocclusion was treated using metal bands cemented to the teeth, which served as anchors for wires that applied corrective forces.

By the 1970s, the orthodontic field welcomed the introduction of standardized brackets made of transparent or semi-transparent non-metallic materials—a milestone that marked significant progress in the discipline. This advancement followed a breakthrough in the 1960s, when the first bracket systems using stainless steel for wire fixation were introduced. These systems stood out for their advantages: high strength, durability, reduced friction between components, improved saliva drainage, decreased accumulation of food residue, and relative ease of processing and shaping [5].

The first transparent brackets made of unfilled polycarbonate were later replaced by reinforced versions using ceramic, fiberglass, or polycarbonate materials with a metal insert to minimize creep [6]. Subsequently, ceramic brackets made from monocrystalline sapphire and polycrystalline ceramics were introduced; however, due to the hardness of these materials, enamel wear could occur.

Eventually, traditional steel arches were replaced with advanced materials—ranging from Optiflex, featuring transparent fibers, to various types of wires treated with unique coatings such as Teflon, epoxy, innovative titanium plastic, and Bioforce [7].

In the recent past—spanning the end of the previous century and the beginning of the current one—the emergence of aligners in orthodontics has been observed. This development is considered a key milestone in the evolution of modern orthodontic science, marking the beginning of a new era in the field, often referred to as the third orthodontic revolution [8].

Aligners, designed as transparent removable trays, are intended to correct various misalignments in the position of individual teeth, as well as in the entire dental arch and bite, once they become permanent. These devices are engineered to apply controlled pressure on the teeth, aligning them and correcting bite anomalies [9].

Clear aligners are custom-made, removable appliances designed for effective, comprehensive cosmetic orthodontic treatment of mild to moderate malocclusions [8]. The appliance ensures gradual tooth movement through sequential sets of plastic aligners, which are worn and replaced at specific intervals throughout the treatment period [3].

In the study by S. Barone et al., a system was developed for a specific patient to simulate orthodontic tooth movements using plastic aligners. The upper and lower dental arches were reconstructed using a combination of optical and radiographic methods. A finite element (FE) model was then created to analyze two different aligner configurations. The authors thus investigated the influence of non-uniform aligner thickness and the initial individual displacement between the aligner and the patient's teeth [10].

In 1998, the American company *Align Technology* introduced the *Invisalign* system to the world—a series of transparent orthodontic trays. These devices differ from traditional braces by allowing removal at specific times, such as during meals or oral hygiene procedures, making them particularly appealing due to their aesthetic advantages. The trays are placed over the teeth to perform correction without the use of additional attachments, requiring daily wear with short breaks [9].

The geometric fit and material properties are among the key factors influencing the device's effectiveness, which, in turn, depends on the choice of material and manufacturing method [7]. As noted by R.L. Boyd et al., since their introduction in 1999, clear aligner systems made from semi-transparent thermoplastic materials using computer scanning and visualization technologies have become an established method of treatment [8].

The main advantages of using aligners include their invisibility during wear—making them highly appealing aesthetically—and the ease of maintaining oral hygiene independently, since they can be easily removed and reinserted.

In addition, aligners protect the oral mucosa and eliminate the risk of enamel damage, as they lack complex metallic or ceramic components. Instead, they use soft, biocompatible material locks. The ease of adaptation and the absence of a foreign-body sensation in the mouth also distinguish aligners from other dental correction methods [3].

The disadvantages of aligners include their limited functionality, as they cannot be used to treat patients with severe malocclusion (such as cases involving large diastemas or spacing), as well as their relatively high cost [11]. Despite the introduction of new materials and auxiliary components in align-

er-based orthodontics, the vast majority of aligners are still manufactured through thermoforming [5].

Conclusion

The modern method of treating malocclusion with aligners allows not only effective correction of dental irregularities but also comfortable orthodontic treatment for the patient. This review has examined the materials used in the construction of aligners, as well as modeling methods and fabrication technologies.

While aligners have certain disadvantages due to their limited indications and high cost, they also hold great promise for the future thanks to their simplicity, practicality, and patient-friendly characteristics.

Conflict of interest

The authors declare no conflict of interest.

Consent to publication

The authors have reviewed the manuscript and have given their consent to its publication.

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Елайнери: загальні характеристики, переваги та недоліки (огляд)

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Вступ. За останнє десятиліття знімні ортодонтичні термопластичні апарати — елайнери — стали широко поширеною альтернативою традиційним фіксованим системам та ортодонтичним апаратам, призначеним для виправлення неправильного прикусу шляхом застосування сил, що викликають певні рухи зубів. Технологія, що використовується у виробництві та застосуванні елайнерів, дозволяє розробляти індивідуальну систему вирівнювання з повним контролем над бажаною товщиною, покриттям та кріпленнями.

Мета: розглянути методи та варіанти моделювання знімних ортодонтичних апаратів — елайнерів — та проаналізувати технології, що використовуються для їх виробництва.

Результати. Основними перевагами використання елайнерів є їхня непомітність під час носіння, що робить їх естетично дуже привабливими, та легкість самостійного підтримання гігієни порожнини рота. Також елайнери забезпечують безпеку для слизової оболонки рота та усувають ризик пошкодження емалі через відсутність твердих металевих або керамічних компонентів. Натомість вони використовують м'які, біосумісні матеріальні замки. Легкість адаптації та відсутність відчуття стороннього тіла в роті також відрізняють елайнери від інших методів корекції зубів.

До недоліків елайнерів належить їхня обмежена функціональність, оскільки їх не можна використовувати для лікування пацієнтів із важким прикусом (наприклад, у випадках великих діастем або проміжків між зубами), а також їхня відносно висока вартість.

Висновок. Сучасний метод лікування неправильного прикусу за допомогою елайнерів дозволяє виправляти зубні порушення та забезпечити комфортне для пацієнта ортодонтичне лікування. Елайнери мають великі перспективи на майбутнє завдяки своїй простоті, практичності та зручності для пацієнта.

Ключові слова: елайнер, брекет-система, ортодонтичні конструкції, ортодонтія, 3D-друк.

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