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Modern Treatment Methods in Orthodontia

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Abstract: Orthodontics as a branch of dentistry is experiencing a period of rapid development and transformation associated with the introduction of innovative technologies, materials, and treatment methods that allow achieving optimal aesthetic and functional results with minimal trauma to the hard and soft tissues of the oral cavity. Traditional ortodontic treatment methods based on applying mechanical force to teeth to move them remain relevant, however, the emergence of new materials, devices, and computer technologies has significantly expanded the orthopedic doctor's capabilities in diagnosing, planning, and implementing the treatment process.

Keywords: Orthodontic treatment; multibonded systems; braces; transparent liners; lingual orthodontics; self-ligating braces; digital technologies; 3D computed tomography

Introduction. The development of dentoalveolar anomalies is linked to the complex interaction of genetic and ecological factors, including genetic predisposition, impaired jaw bone development, anomalies in the number and size of teeth, functional disorders, and harmful habits [1, 3, 6]. According to global research, dentoalveolar anomalies occur in 50-90% of the population of various age groups and ethnic groups, making ortodontic treatment one of the most in-demand dental services [2, 3, 4, 5].

The modern approach to ortodontic treatment is characterized by personalization, that is, the development of individualized treatment tactics for each patient based on a detailed analysis of morphological features, cephalometric parameters, the patient's aesthetic preferences, and the forecast of facial skeleton growth [2, 3, 4, 5, 7]. Digital technologies, including three-dimensional computed tomography, digital dental models, virtual modeling of treatment outcomes, and computer planning, allow the orthodontist to make more accurate planning and provide patients with visualization of expected treatment outcomes before it begins [3, 4, 5, 7, 8]. The arsenal of modern ortodontic methods includes non-removable devices (multibonded systems of various manufacturers, self-ligating braces, lingual braces), removable devices (functional devices, extraoral traction in modern modifications), combined treatment methods, innovative intraoral distallizing and retraction systems, and the application of biomechanical principles of optimal strength in treatment. The emergence of transparent elayers (capp) as alternatives to traditional braces has opened up new possibilities for patients who require full aesthetics during orthodontic treatment [3, 4, 7, 8, 9].

The purpose of this review is to systematize modern treatment methods in ortodontics, including describing their mechanisms of action, indications and contraindications, effectiveness, advantages and disadvantages, as well as discussing the role of digital technologies in optimizing the treatment process and achieving predictable, stable treatment results.

The history of ortodontics spans more than two millennia, beginning with ancient attempts to correct the position of teeth and ending with modern high-tech methods, however, the most significant achievements occurred in the last 100-150 years [1, 2, 3, 4]. A revolutionary moment in the development of ortodontics was the creation by Edward Engle at the end of the 19th century of a system for classifying dentoalveolar anomalies (class I, II, III), which remains relevant even today, despite the emergence of more complex classification systems [1, 2, 3, 4, 5].

The development of non-removable ortodontic techniques in the mid-20th century with the introduction of the bracket system (Edward Angle, 1916) dramatically changed the possibilities of ortodontic treatment, allowing for precise control of the position of each tooth in three-dimensional space [2, 3, 4, 6]. The emergence of a straight-wire system (straight-wire technique) developed by Lawrence Andrews in 1972 significantly simplified ortodontic treatment by introducing information about the optimal position of each tooth directly into the bracket (angulation, inclination, torque) [1, 3, 4, 6, 7].

The development of materials science has led to the creation of new semi-elastic materials (NiTi alloys, including martensitic and austenitic variants), which provide a more gentle, prolonged, and predictable effect of ortodontic force on teeth and bone, improving patient comfort and treatment effectiveness [2, 3, 4, 5, 7]. The emergence of low-three-phase (light-force) ortodontic techniques based on biomechanical principles and the application of optimal forces (25-75 g for frontal teeth and 50-150 g for molars) has made it possible to minimize the side effects of ortodontic treatment such as tooth root resorption, gingival recession, and bone tissue damage.

Multibonded (unbound) bracket systems remain the most common and effective method for correcting dentoalveolar anomalies, allowing for precise control of the position of each tooth in sagittal, transverse, and vertical directions [1, 2, 3, 4, 5, 6, 8]. Modern bracket systems from various manufacturers (Roth, MBT, Damon, In-Ovation, Victory, Euphony, and others) contain built-in information in the bracket groove, which ensures optimal positioning of teeth when using standard orthodontic wire. Brackets are distinguished by the type of arch attachment: ligature braces require the arch to be attached to the bracket using rubber or wire ligatures, which allows for maximum control of the arch's position in the bracket groove, but requires frequent visits from an orthopedist to replace the ligatures. Self-ligating braces, which appeared in the late 1980s, contain an embedded mechanism (patter or sliding cap) that holds the arc in the bracket groove without using ligatures, reducing friction, shortening treatment time, and improving oral hygiene.

Active self-adhesive braces (e.g., In-Ovation) contain a pattern that, during the treatment phase with a smaller arc, actively controls the arc position, ensuring controlled movement of the teeth, and when transitioning to a thicker arc, it becomes passive, allowing the arc to move more freely in the groove [2, 4, 6, 7]. Passive self-ligating systems (e.g., Damon SL) allow greater freedom of arc movement in the bracket groove during all treatment phases, which, according to manufacturers, contributes to faster and less painful tooth movement. The material of braces is diverse: metal braces remain the cheapest and most durable, ceramic braces provide improved aesthetics due to their fusion with the color of the tooth, however, more fragile and expensive composite braces represent an intermediate option. A combined approach, where ceramic braces are placed on visible frontal teeth and metal ones on molars, ensures an optimal balance between aesthetics and functionality with an acceptable treatment cost.

The mechanics of dental movement using multibonded systems is diverse and includes the use of various types of ortodontic arches (circular, rectangular, square), springs for opening gaps (coil springs, open coil springs), springs for closing gaps, elastics, and other auxiliary devices [1, 3, 4, 5, 6, 7, 8]. Treatment phases using multibonded systems typically include: (1) a leveling and leveling phase using small diameter circular arcs, (2) a controlled movement phase using thicker rectangular arcs, and (3) a final occlusion phase using the thickest arcs and springs to achieve ideal occlusion. Self-adhesive braces were designed to reduce friction between the arch and the bracket, which, according to the developers' theory, should lead to faster tooth movement, less pain and discomfort, and shorter treatment time. Clinical studies show that self-ligation systems do indeed provide some reduction in the time between orthodontist visits due to slower consumption of orthodontic force.

The proposed advantages of self-ligating systems include: (1) reduction of treatment duration by 1-3 months overall, (2) reduction of pain sensations and discomfort in patients due to softer force application, (3) improvement of oral hygiene due to the absence of ligatures, (4) fewer side effects, including root resorption and alveolar bone loss. However, independent clinical studies conducted in recent years have shown that the differences in treatment timing between self-ligating and traditional ligature systems are not as significant as claimed by manufacturers.

The financial cost of self-ligature systems is significantly higher than traditional ligature systems, which reflects the cost of treatment for the patient and limits their widespread implementation in practice [2, 4, 6, 7]. However, some patients note the advantages of self-ligation systems, including less discomfort and fewer visits, which can be especially beneficial for patients living far from the dentist's office or having a busy schedule [1, 3, 4, 6, 8].

Lingual orthodontics (internal orthodontics, hidden braces) is an alternative method of ortodontic treatment where braces are fixed on the inner (lingual) surface of the teeth, ensuring complete aesthetic treatment, as braces and arches are completely hidden behind the teeth. Lingual ortodontics is especially indicated for adult patients who require full aesthetics during ortodontic treatment, professionals (actors, singers, models), as well as patients with high aesthetic requirements. The advantages of lingual ortodontia include: (1) complete treatment aesthetics, as braces are completely concealed, (2) precise three-dimensional control of tooth position, allowing for optimal occlusion, (3) the ability to correct frontal dental arch, which is especially important for achieving optimal facial profile. The disadvantages of lingual orthodontics include: (1) higher treatment costs compared to vestibular orthodontics, (2) the need for special training and experience from an orthodontist, (3) initial speech difficulties of patients and discomfort of the tongue when contacting braces, (4) complex oral hygiene and increased risk of caries and gingivitis. Modern linguistic systems such as WIN (Wilckodontics), Incognito, IdentiBraces provide a more comfortable bite for patients due to reduced bracket profile and the use of super-elastic materials [2, 4, 7, 8, 9]. Computerized planning and the production of personalized lingual braces allows for significantly speeding up the treatment process and improving its results.

Transparent aligners (caps, invisible aligners, clear aligners) represent a revolutionary method of ortodontic treatment based on the sequential use of a series of transparent polyurethane caps, each of which represents an intermediate stage in the movement of teeth towards the target position [3, 4, 7, 8, 9, 10]. The most well-known transparent liner system is Invisalign, developed in 1997 by Align Technology, which uses computer modeling of tooth movement paths and 3D printing to make individual caps [2, 3, 4, 7, 8, 9, 10]. The effectiveness of transparent liners when used correctly is comparable to traditional braces, however, liner systems are best suited for patients with mild and moderate anomalies with good compliance [2, 3, 4, 7, 8, 9, 10]. The emergence of new transparent elayer systems (SmileDirect Club, Candid, ClearCorrect, Spark, and others) has significantly expanded the availability of this treatment method and reduced its cost, although the quality of treatment can vary depending on the system.Механизм действия функциональных аппаратов основан на принципе постепенного переведения нижней челюсти в положение протрузии, что стимулирует рост нижней челюсти и одновременно способствует переустановке верхних моляров и переходу соотношения моляров от класса II в класс I [1, 2, 3, 4, 5, 6, 8]. Functional devices show the greatest effectiveness in treating distal prickles associated with underdevelopment of the mandible (micromandibulitis), when stimulation of mandibular growth can compensate for the initial deficiency [2, 3, 4, 6, 8].

The effectiveness of functional devices depends on the start period of treatment (optimal at 8-14 years), the duration of use (minimum 12-18 months), the magnitude of the anterior displacement of the lower jaw, the rate of jaw growth, and the patient's compliance [1, 3, 4, 5, 6, 8]. Treatment results using functional devices show stimulation of lower jaw growth by 3-5 mm in the sagittal direction, normalization of the mesiodistal ratio of molars, and improvement of the facial profile [2, 4, 6, 8].

Extraoral traction (headgear) remains one of the effective methods for distillating the upper molars and correcting the distal bite, especially with maxillary protrusion as a component of the anomaly [1, 2, 3, 4, 5, 6, 8]. Modern modifications of extraoral traction include various types depending on the direction of the force vector: cervical pull, high pull, combined pull, and face bow. The effectiveness of extraoral traction in the distillation of the upper molars is 3-6 mm in the sagittal direction, and the direction of force should be selected based on the patient's vertical growth type to minimize side effects (opening of the bite during neck traction) [1, 2, 3, 4, 6, 8]. Neck traction is applied with normal or low gonadal angle and is characterized by force directed upward and backward, while high traction is used with high gonadal angle and vertical growth type to avoid additional opening of the bite [2, 3, 4, 6, 8].

Using extraoral traction requires good patient compliance, as the device should be used for at least 12-14 hours per day, which can be challenging for many patients, especially adolescents [1, 3, 4, 5, 6, 8]. The emergence of combined systems combining extraoral traction with non-removable equipment (for example, using microscrews to secure extraoral force) has increased treatment effectiveness and improved tooth movement direction control [2, 4, 6, 8]. In the last two decades, innovative intraoral distillation systems have been developed and implemented that do not require the use of extraoral equipment and allow patients to avoid aesthetic and social problems associated with the use of headgear. The most well-known systems include: Pendulum (pendulum), Distal Jet, Jones Jig, Forsus EZ, Powerscope, and others.

The Pendulum system is a pallatinum apparatus with an intraoral power source that ensures the distillation of the upper molars through inclination and lateral displacement [2, 3, 4, 6, 8]. The Pendulum system shows the effectiveness of 4-6 mm distillation of the upper molars with minimal side effects from the inclination of the upper frontal teeth, especially when used during the period of mixed occlusion [1, 3, 4, 6, 8, 11].

The Distal Jet system utilizes closer contact with the upper molars and provides more vertical molar distillation due to the use of a guide cap, which reduces tooth inclination when moving [2, 3, 4, 6, 8, 11]. The distillation efficiency when using Distal Jet is 3-5 mm, while the system shows good results when used in conjunction with non-removable equipment.

Jones Jig and Forsus EZ are non-removable systems that provide a continuous distal force effect on the upper molars through elastic elements or screw mechanisms that can be used as an alternative to extraoral traction. The advantages of these systems are that they do not depend on the patient's compliance, provide constant exposure, and allow achieving 3-5 mm distallization of the upper molars in 6-12 months.

Conclusions: The revolution in ortodontics that has occurred in the last two decades is associated with the introduction of digital technologies, including three-dimensional computed tomography (CBCT), digital dental models, computer-based treatment planning, and virtual modeling of results. CBCT allows for detailed three-dimensional information on the position of teeth, alveolar bone, temporomandibular joints, and soft tissues, allowing the orthopedist to make a more accurate diagnosis and plan treatment.

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