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Application of Twin-Block Appliance in the Treatment of Skeletal Class Ⅱ maloc-clusion

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Abstract: Class II skeletal malocclusion has a high incidence rate, significantly impacting patients oral function and mental health, making early intervention crucial. The Twin-Block appliance, invented by Dr. Clark in 1982, has seen substantial improvements in clinical application value through multiple iterations. The optimal timing for its use should be determined based on a comprehensive evaluation of the patients growth and developmental status, with better efficacy observed during adolescence and limited application in adult maxillary reconstruction. This appliance effectively improves the morphology of oral hard and soft tissues, upper airway function, and temporomandibular joint status, although studies on the upper airway are limited by small sample sizes. Compared to appliances such as Herbst and Activator, Twin-Block has both advantages and limitations, necessitating clinical selection based on specific needs. This article synthesizes the latest domestic and international research findings to elaborate on the application and research progress of Twin-Block in treating Class II skeletal malocclusion. It covers the therapeutic principles, structural composition, evolutionary improvements, optimal timing for use, clinical outcomes, and comparative analysis with various removable appliances. These findings lay the foundation for the future development of Twin-Block toward digitalization, personalization, and precision, providing a scientific theoretical basis for optimizing clinical treatment plans for Class II skeletal malocclusion and exploring new approaches and directions for functional correction of this type of malocclusion.

Keywords: Twin-Block Appliance; Class II Skeletal Malocclusion; Orthodontic Outcome; Research Progress.

1. Introduction

Class II skeletal malocclusion is a common dental and maxillofacial deformity in orthodontic clinical practice.[1]It accounts for 20%~30% of all malocclusion deformities, typically presenting as sagittal misalignment of the maxillofacial bones. The primary manifestations include mandibular retrusion or maxillary protrusion, usually caused by the mandibles retrocession relative to the maxilla.[2-4]This type of malocclusion not only often presents with severe aesthetic issues but also leads to occlusal dysfunction, thereby impairing the patients oral physiological functions such as mastication and speech, reducing food digestion and absorption efficiency, and significantly affecting the patients quality of life.[5]Clinical studies have confirmed that abnormal facial morphology is prone to induce negative psychological states such as inferiority and anxiety in patients, thereby affecting their social activities and mental health.[6]Therefore, early and effective intervention for Class II skeletal malocclusion is of great significance in improving patients oral function, optimizing facial aesthetic morphology, and enhancing mental health. Epidemiological survey data indicate that Class II malocclusion has a high incidence rate among adolescents. Implementing early orthodontic intervention during the peak growth and development period can fully mobilize the patients inherent skeletal growth potential, thereby achieving ideal orthodontic outcomes that would be difficult to attain without orthognathic surgery in adulthood.[7-8]Functional orthodontic appliances are an alternative treatment option for patients with Class II malocclusion who have significant mandibular retrusion but still possess good growth potential.[9-10]Such functional orthodontic appliances can stimulate mandibular growth and guide its development in the downward and anterior direction by utilizing the mandibular posture generated by the oral and facial muscles.[11]Among the numerous functional orthodontic appliances available for correcting mandibular retrusion, the Twin-Block appliance has been widely adopted in clinical practice due to its ease of use, customization, and high patient compliance.[12]

In recent years, numerous scholars have conducted extensive research on the component modifications of Twin-Block appliances, their clinical orthodontic efficacy, and comparative analyses of their therapeutic outcomes with other orthodontic devices. However, limited discussions have focused on the optimal timing for Twin-Block appliance application and the changes in the upper airway and temporomandibular joint (TMJ) before and after treatment. This article provides a comprehensive review of the therapeutic principles and structural composition of Twin-Block appliances, their evolutionary process, appropriate application timing, clinical efficacy, and comparative analyses with other functional orthodontic devices. It systematically summarizes the progress of Twin-Block appliance applications in the treatment of skeletal Class II malocclusions, delves into its therapeutic mechanisms and clinical key points, and aims to provide a scientific theoretical basis for optimizing clinical treatment strategies for skeletal Class II malocclusions. Additionally, it explores new approaches and directions for functional orthodontic management of this type of malocclusion.

2. The Principle and Structure of Twin-Block Orthodontic Appliance, Its Development and Improvement Process and The Appropriate Time for its Application

2.1. The Correction Principle and Structural Composition of Twin-Block Orthodontic Appliances

The Twin-Block appliance is a functional orthodontic device currently widely used both domestically and internationally. Invented by Dr. Clark of Scotland in 1982, it primarily consists of maxillary and mandibular bite guide plates with oblique surfaces, respectively located in the upper and lower jaws. The bite contact surfaces of the upper and lower guide plates are interlocked at a 70-degree angle, enabling functional anterior displacement of the mandible during occlusion.[13]The biological principle of the Twin-Block orthodontic appliance is to stimulate condylar remodeling and promote temporomandibular joint remodeling by forcibly advancing the mandible, thereby facilitating sagittal skeletal growth.[14]The core mechanism of this orthodontic appliance lies in fully mobilizing mastication, the most active functional movement in the human oral cavity. During the execution of masticatory actions, the resulting powerful functional forces serve as the key source of orthodontic efficacy. Simultaneously, as occlusal and soft tissue relationships improve, it achieves superior facial contour and perioral aesthetic outcomes.[15]

The Twin-Block structure consists of an upper and a lower jaw component. The upper jaw appliance includes retention components such as modified arrow clips and spherical interdental hooks. Depending on the occlusal type, it may be equipped with a double-curved labial arch, lingual spring, or midpalatal spiral expansion spring, along with a plastic base plate featuring a 70° guide slope to direct mandibular protrusion. Auxiliary components can adjust the position of the upper anterior teeth and the width of the upper dental arch. The lower jaw appliance is retained by a circular arrow clip for the first premolar and an interdental hook for the lower anterior teeth, paired with a plastic base plate that also has a 70° guide slope. The lingual side of the base plates canine area is thickened to prevent fracture, and the guide slope avoids the occlusal surface of the first mandibular molar to avoid hindering eruption.

2.2. Development of Twin-Block Orthodontic Appliances

The initial Twin-Block appliance featured a 45° angle between the upper and lower occlusal interfaces, which was later adjusted to 70° by Dr. Clark. This modification significantly enhanced the orthodontic efficacy and facilitated more effective mandibular functional forward movement.[16]The use of Twin-Block orthodontic appliances often induces lingual inclination of the upper anterior teeth and labial inclination of the lower anterior teeth.[17-18]Excessive lingual inclination of the anterior teeth and excessive labial inclination of the lower anterior teeth further exacerbate the deterioration of the positional relationship between the dental roots and alveolar bone in the anterior tooth region. Relevant studies have confirmed that the incisor cap can effectively limit the elongation and labial inclination of the lower anterior teeth.[19]Based on this, in the clinical design and fabrication of Twin-Block appliances, orthodontists generally opt to add a premolar cap in the distal third region of the lower anterior teeth. Since traditional Twin-Block appliances are often designed as removable systems for both the upper and lower jaws, their orthodontic efficacy frequently depends on patient compliance. Poor patient cooperation can significantly compromise the achievement of desired outcomes.[20]During the mixed dentition period, traditional removable Twin-Block appliances often struggle to achieve optimal occlusal retention. To address these limitations, fixed Twin-Block appliances were developed. Designed for direct dental bonding, Twin-Block eliminates the issue of suboptimal treatment outcomes caused by delayed or insufficient appliance wear in removable systems. This stable retention method ensures continuous appliance effectiveness, facilitating more efficient mandibular growth and occlusal alignment. In recent years, Chinese researchers have proposed SGTB (Sagittal Guided Twin-Block), a novel approach to address these challenges.[21]The core innovation lies in modifying the removable structure to a semi-fixed design, where the maxillary portion of the orthodontic appliance is bonded to the teeth and integrated with the bracket system, facilitating anterior alignment and resolving sagittal misalignment.[22]This enables simultaneous orthopedic and orthodontic treatment. The maxilla typically incorporates an arch expander, replacing the palatal resin connection with bracket arch expanders or split arch expanders to secure the occlusal pads, thereby adjusting the occlusal relationship while correcting malocclusion and bone volume imbalance. Patients with Class II bony malocclusion often exhibit maxillary overdevelopment. The external traction Twin-Block appliance combines traditional Twin-Block functional appliances with external traction devices, primarily used to correct severe maxillary protrusion and Class II bony high-angle malocclusion. Through sustained external force, it maximizes the correction of sagittal misalignment between the maxilla and mandible.[23] Through multiple rounds of technical refinement and optimization, the clinical value of Twin-Block orthodontic appliances has been significantly enhanced. This not only substantially reduces the incidence of adverse reactions during treatment but also effectively improves patient compliance, ultimately contributing to more ideal orthodontic outcomes in clinical practice.

2.3. Optimal Timing for Twin-Block Orthodontic Appliances

The optimal timing for the application of Twin-Block orthodontic appliances remains a widely debated issue in the field of dentistry. Sandler et al.[24]The proposed viewpoint is that the initial orthodontic intervention with Twin-Block appliances should not be initiated too early, and the optimal clinical timing should be selected after the complete eruption of the patients four first premolars. Conducting orthodontic treatment at this stage not only ensures ideal retention of Twin-Block appliances but also shortens the duration of the subsequent retainer phase, facilitating a smooth transition to the Phase II orthodontic treatment stage. Inchingolo AD et al. conducted a clinical study comparing skeletal and airway changes in Class II malocclusion patients treated with Twin-Block appliances during the prepubertal and pubertal stages.[25]The final conclusion is that if the goal is to

promote mandibular growth, elevate the chin position, and improve respiratory function, the initiation of Twin-Block orthodontic treatment should be delayed until adolescence. The efficacy of this appliance is highly dependent on the growth and remodeling potential of the patients jawbone. However, in adult patients, the craniofacial skeleton is fully developed, with bone sutures tending to close, and the jawbones growth and remodeling capacity significantly declines. Consequently, Twin-Block orthodontic appliances are less effective in achieving significant bony remodeling through functional mechanical stimulation, limiting their application in adult orthodontic treatment. Nevertheless, some clinical cases and related studies have demonstrated that this appliance may have certain positive effects in adult jaw position reconstruction. For example, researchers such as Xue Qing conducted clinical studies on adult patients with Class 2, Division 2 Ankylosis combined with temporomandibular joint disorder (TMD).[26]Following mandibular reconstruction under the guidance of the Twin-Bloc k appliance, the conclusion was drawn that the orthodontic mandibular reconstruction treatment plan not only effectively improves the clinical symptoms of temporomandibular joint clicking in adult patients but also promotes the physiological positioning of the condyle in the articular fossa through guided mandibular protraction, thereby creating favorable conditions for the functional health of the temporomandibular joint disc-condyle complex. Simultaneously, the correction of abnormal occlusal relationships through orthodontic treatment also plays a positive role in the recovery and improvement of oral occlusal function. Therefore, in the clinical practice of Twin-Bloc appliance, orthodontists can scientifically determine the appropriate timing for initiating orthodontic treatment based on the patients individual growth and development status, type of malocclusion, and clinical treatment objectives, thereby enhancing the final orthodontic outcomes.

3. Clinical Efficacy of Twin-Block Orthodontic Appliances

3.1. Changes of Oral Hard Tissues Before and After Treatment with Twin-Block Appliance

The changes in oral hard tissues before and after the use of Twin-Block orthodontic appliances are primarily reflected in alterations of jawbone and tooth positions. Regarding changes in jawbone position, studies have demonstrated[27-28]The Twin-Block orthodontic appliance can significantly increase mandibular length by guiding the mandible forward, effectively correcting sagittal misalignment of the mandible. While promoting mandibular forward displacement, the Twin-Block orthodontic appliance also regulates the stress exerted by the orofacial muscles on teeth and bones to limit maxillary growth.[29]This lays the foundation for optimizing the occlusal relationship between the maxilla and mandible. Regarding changes in tooth position, studies have demonstrated[30]The Twin-Block appliance demonstrates significant efficacy in reducing anterior overjet and improving molar relationships. The role of Twin-Block functional appliances in regulating the growth and development of the maxillofacial bones has been widely validated by most scholars in the field of orthodontics. A comprehensive understanding of the mechanisms by which Twin-Block appliances affect the jaw and teeth is essential for their optimal application in treating Class II skeletal malocclusions.

3.2. Changes of Oral Soft Tissue Before and After Treatment with Twin-Block Appliance

The changes in oral soft tissues before and after the use of Twin-Block orthodontic appliances are primarily reflected in alterations of facial profile, which are often quantified through indicators such as facial projection, position of the upper and lower lips, and the position of the anterior chin point. Quintao et al.[31]Clinical studies conducted by scholars have also confirmed that patients with Class II, Division 1 malocclusion treated with the Twin-Bloc k appliance exhibit significant improvement in maxillofacial soft tissue profile. This is specifically manifested as a reduction in facial projection values, retraction of the upper lip position, and a marked anterior shift of the soft tissue chin point. Sharma et al.[32]Clinical measurements and data analysis suggest that during functional orthodontic treatment with Twin-Block appliances, the ratio of anterior soft tissue displacement to anterior hard tissue displacement in the chin can reach 1:1.2. Singh et al.[33]Through systematic modeling and data analysis using finite element scale analysis as a quantitative research method, the clinical efficacy of Twin-Block orthodontic appliances in optimizing the lateral facial soft tissue morphology has been confirmed. Therefore, the application of Twin-Block orthodontic appliances for the correction of Class II skeletal malocclusion can effectively improve the facial soft tissue profile, resulting in a more harmonious and aesthetically pleasing facial appearance.[34]

3.3. Changes in Upper Airway Before and After Treatment with Twin-Block Appliance

The Twin-Block orthodontic appliance achieves functional anterior mandibular guidance, utilizing the traction of associated attached muscles and ligaments to induce positional changes in structures such as the hyoid bone, tongue, and upper airway dilators. This effectively expands the spatial volume of the upper airway, thereby improving ventilation function.[35-36]Current clinical studies have demonstrated that the combined use of Twin-Block orthodontic appliances with arch expanders yields favorable clinical outcomes.[37]Liu Zeting et al.[38]A clinical study was conducted on patients with mandibular retrognathia combined with maxillary arch constriction and malocclusion. The results demonstrated that after orthodontic intervention using Twin-Block appliances combined with maxillary arch expansion appliances, significant increases were observed in the distance from the hard palate posterior border to the soft palate posterior border (SPP-SPPW), the distance from the maxillary posterior border to the posterior pharyngeal wall (U-MPW), the minimum sagittal diameter of the airway (PAS), and the distance from the soft palate tip to the posterior pharyngeal wall (V-LPW). The intergroup differences were statistically significant. These findings suggest that a functional orthodontic treatment plan with mandibular forward guidance achieved significant sagittal expansion of the oropharyngeal and laryngopharyngeal planes of the upper airway. The clinical study results conducted by Guo Jinghan et al. indicated that the treatment protocol combining

maxillary arch expansion technology with Twin-Block appliances not only effectively increased the overall volume of the upper airway in children with mouth breathing malocclusion but also promoted the development of the upper airway morphology toward a physiological oval shape, thereby improving the mouth breathing pattern of the patients and facilitating the reconstruction of normal nasal breathing patterns.[39]Zreaqat et al.[40]The completed clinical study results demonstrate that for pediatric patients with obstructive sleep apnea syndrome (OSAS) caused by skeletal Class II, Division 1 malocclusion, the implementation of orthodontic intervention using the Twin-Block appliance can effectively optimize sleep-related respiratory parameters, maintain patency of the upper airway, and thereby significantly improve sleep efficiency. In summary, the Twin-Block appliance holds significant clinical application value in addressing pediatric mouth breathing disorders and obstructive sleep apnea syndrome. Currently, most domestic and international studies on the changes in the upper airway before and after Twin-Block appliance treatment suffer from limitations such as small sample sizes and insufficient monitoring duration. To more accurately understand the changes in the upper airway, further clinical research is needed to enhance sample sizes and extend monitoring periods.

3.4. Changes of Temporomandibular Joint Before and After Treatment with Twin-Block Appliance

In recent years, the impact of Twin-Block orthodontic treatment on the temporomandibular joint has also become a key focus in clinical practice. Che Chengna et al.[41]The researchers enrolled 15 cases treated with Twin-Block appliances, acquiring cone-beam computed tomography (CBCT) images before and after orthodontic intervention for three-dimensional reconstruction. Concurrently, relevant measurement indicators were collected and statistically analyzed. The study results demonstrated that after mandibular forward alignment using Twin-Block appliances, significant remodeling responses were observed in the condylar tissues of patients, specifically manifested as increased condylar height, volume, and surface area, along with anterior and inferior displacement of the condyles relative to the articular fossa. On this basis, the temporomandibular joint achieved a dynamic equilibrium state with structural morphology and physiological function adapted to the new mandibular forward alignment position. Elfeky et al. [42]The conducted controlled study also confirmed that, compared with the control group without intervention, the subjects treated with Twin-Block orthodontic appliances exhibited a significant trend of increased condylar volume, a reduction in the width of the anterior and intermediate joint spaces, and a corresponding widening of the posterior and superior joint spaces. Additionally, the condylar position within the articular fossa showed a marked anterior shift compared to the control group. There were also conference reports.[43]Clinical studies demonstrate that Twin-Block orthodontic appliances provide definitive clinical outcomes for patients with anterior tooth malocclusion accompanied by temporomandibular joint (TMJ) reducible preprotrusion. This treatment modality effectively replaces traditional positioning occlusal pads, offering significant clinical applicability. However, it has limitations including patient compliance requirements, limited remodeling effects in adults, and potential short-term joint discomfort risks.

4. Application of Twin-Block Orthodontic Appliances and Multiple Moving Orthodontic Appliances

4.1. Comparison of Twin-Block and Herbst Orthodontic Appliances

The Herbst appliance is a fixed-function orthodontic device commonly used for correcting Class II mandibular retrognathia in developing patients and malocclusion. Both the Twin-Bloc appliance and the Herbst appliance can promote mandibular forward movement, as demonstrated by scholars such as Taylor et al.[44]Clinical measurements revealed that in cases treated with the Herbst appliance, the mandible achieved a growth increment of 4.7 mm, while the chin position exhibited a downward displacement of 2.2 mm and a forward displacement of 1.6 mm, respectively. Moaiyad et al.[45]The completed comparative study results demonstrated that the Herbst appliance exhibited superior orthodontic efficacy in improving anterior tooth coverage compared to the Twin-Block appliance. This therapeutic difference is likely attributable to the fact that the Herbst appliance is a fixed dental device, which cannot be removed by the patient, thereby ensuring a longer clinical wearing duration. Studies have indicated that[46]The results demonstrated that both the Herbst and Twin-Block orthodontic appliances could achieve anterior mandibular guidance during treatment, thereby promoting the anterior and inferior displacement of the condylar process. After discontinuation of the appliances, the condylar process gradually returned to its original position in Herbst patients, while in Twin-Block patients, it maintained a midline position for a short period but still exhibited an overall anterior displacement trend. The Herbst appliance, through mandibular guidance, facilitated adaptive spatial repositioning of the hyoid bone and lingual body, thereby expanding the effective volume of the upper airway and reducing airway resistance during ventilation, ultimately leading to significant improvement in airway patency.[47]Both the Herbst and Twin-Block orthodontic appliances share a core mechanism of mandibular advancement to stimulate mandibular growth. Their primary objectives are to improve molar relationships and reduce anterior overjet. Additionally, both devices can promote mandibular displacement to drive lingual bone advancement, expand upper airway volume, and positively influence the morphology and positioning of the temporomandibular joint.

4.2. Comparison of Twin-Block and Activator Orthodontic Appliances

In the design of the Activator orthodontic appliance, the external arch and internal arch are embedded within the resin baseplate, while the external arch extends beyond the baseplate through the space between the first and second premolars of the maxilla. This is combined with the headgear to perform high-tension traction therapy. The forces generated by this orthodontic device can simultaneously pass through the impedance center of the maxilla and the maxillary arch, thereby achieving dual inhibitory effects on the vertical and sagittal growth of the maxilla and alveolar

bone.[48]Compared with the Twin-Block appliance, the Activator appliance is larger in volume, and patients may experience dysarthria and masticatory difficulties during initial wear, resulting in relatively lower compliance. Yang Yuhong et al.[49]Studies have shown that the Twin-block functional appliance and the Activator appliance are essentially equivalent in correcting Class II mandibular retrognathia, but the Twin-block functional appliance is more advantageous in improving the position of the hyoid bone and better in modifying the airway morphology. The Activator appliance, on the other hand, is based on myogenic force induction as its core mechanism, with relatively mild and elastic corrective forces, focusing more on adjusting the dynamic balance of the perioral muscle groups and indirectly guiding mandibular growth. Therefore, in clinical practice, the choice between the two appliances should be based on the patients specific condition to achieve optimal orthodontic outcomes.

Comparison of Twin-Block and FrankelII Orthodontic Appliances

The FrankelII appliance is a removable functional orthodontic device for the mandible. This device utilizes the unique structure of the buccal screen and the neuromuscular functional remodeling mechanism to maintain the mandible in a stable forward position. By adjusting the dynamic balance of the perioral muscle groups, it promotes mandibular growth and development. Its orthodontic effects are similar to those of passive muscle function training devices. Campbell et al.[50]Findings: There was no significant difference in clinical treatment duration between the Frankel II appliance and the Twin-Block appliance. The incidence of adverse events caused by both devices was at the same level, and patient and family acceptance of the two treatment regimens was essentially consistent. Some studies[51]The results demonstrated that the Frankel II appliance has no limiting effect on maxillary development, whereas the Twin-Block appliance exhibits a certain inhibitory effect on maxillary development. The Twin-Block appliance, with its advantages of precise mechanical force application, high orthodontic efficiency, and excellent oral adaptation, is more suitable for moderate to severe Class II malocclusion cases where clear requirements for treatment progress are needed. In contrast, the Frankel II appliance is characterized by strong soft tissue shaping capability and superior muscle function adjustment, making it more appropriate for mild to moderate cases requiring simultaneous improvement of oral muscle group dynamic balance.

4.3. Comparison of Twin-Block and Invisible A6 Orthodontic Appliances

The Times Angel A6 Invisalign is a novel dual-jaw plate orthodontic device developed by the company. This orthodontic system innovatively integrates the core therapeutic concept of Twin Block orthodontic appliances with a bracketless transparent aligner fabricated using digital modeling and 3D printing technology. It enables precise tooth positioning while guiding the forward displacement of the mandible. Zhou Jiaqi et al.[52]Discovery: Based on the data from the study sample, the unilateral force generated by the A6 appliance was (2.51±0.51) N when the mandibular lead length was in the range of 2.6–7.4 mm. This data also represents the first publicly reported measured force value in clinical applications of double-arch plate appliances. This force value is higher than the force level of conventional Class II traction and lower than the threshold force of orthodontic treatment. Moreover, its magnitude is positively correlated with the mandibular lead length and negatively correlated with the vertical opening of the bite. Deng Yingjie et al. [53]It is concluded that in the short term, both Twin-block and invisible orthodontic appliance A6 exhibit negligible effects on joint socket bone remodeling. Both devices can significantly improve condylar retroversion without causing bilateral force imbalance or unilateral overload in the temporomandibular joint, demonstrating consistent safety profiles. Therefore, the clinical selection between these two appliances should be comprehensively evaluated based on factors such as the severity of malocclusion, developmental stage, aesthetic requirements, and financial constraints.

5. Look into the Distance

The Twin-Block appliance, as a classic functional orthodontic device for the correction of Class II skeletal malocclusion, has undergone decades of development and refinement, achieving significant progress in orthodontic design, timing determination, and efficacy evaluation. Its clinical value in promoting mandibular growth, improving temporomandibular joint function, and optimizing upper airway and soft tissue morphology has been widely validated. Although current research still faces challenges such as insufficient long-term stability of orthodontic effects and incomplete personalized systems, the continuous advancement of digital orthodontics, artificial intelligence, and molecular biology technologies will drive the Twin-Block appliance toward digitalization, personalization, and precision. Research on its orthodontic mechanisms will also deepen, and its clinical applications will expand further. In the future, through interdisciplinary research and large-sample clinical validation, the Twin-Block appliance will play a greater role in the correction of Class II skeletal malocclusion, providing more efficient, safer, and personalized treatment options to achieve the dual goals of functional and aesthetic orthodontic outcomes.

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