Review Article

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Mandibular Expansion Using Bihelix Appliance : A Comprehensive Review

Abstract:
Mandibular expansion is a critical aspect of orthodontic treatment, particularly for addressing transverse mandibular deficiencies and dental crowding. Traditional non-extraction methods have shown limited success due to their reliance on dental tipping rather than true skeletal expansion. The Bihelix appliance offers a promising alternative by facilitating controlled, non-surgical mandibular expansion through biomechanical force application. This review explores the biological and mechanical principles governing mandibular expansion, the fabrication and activation of the Bihelix appliance, and its impact on bone remodeling. Clinical studies suggest that the appliance can achieve stable arch width increases with long-term retention, minimizing the risk of relapse. Additionally, the Bihelix provides a practical solution for expanding the mandibular arch while maintaining periodontal health and occlusal stability. As advancements in orthodontic biomechanics continue, the Bihelix appliance represents a viable option for non-extraction treatment, enhancing patient outcomes in managing transverse deficiencies. Further research is necessary to optimize treatment protocols and long-term efficacy.

Key-words: Mandibular Expansion, Bi-helix Appliance, Orthodontic Treatment,Skeletal Expansion, Dental Crowding, Transverse Deficiency, Bone Remodelling,Arch Development, Non-Extraction Orthodontics, Stability and Relapse.

Introduction:

Mandibular Expansion in Orthodontics:

Orthodontists have historically faced the challenge of addressing dental crowding, utilizing various treatment approaches such as tooth extractions, arch expansion, interproximal enamel reduction, incisor flaring, and molar uprighting. Recently, non-extraction treatments have gained renewed focus, particularly for patients with significant crowding. Proffit reported that the need for extracting four premolars at the Orthodontic Clinic of the University of North Carolina rose from 10% in 1953 to 50% in 1963, stayed between 35-45% until the early 1980s, then sharply declined by 28%, returning to 1950s levels by 1993, with a recent trend toward non-extraction[1]. Kaida et al. found that extraction rates in their hospital remained high between 1971 and 1996, with rates of 77.7% in 1976 and 75.2% in 1981, especially for upper and lower premolars[2]. However, advancements in expansion techniques, such as the Bihelix appliance, have expanded space management options, leading to significant mandibular arch expansion and contributing to reduced extractions in orthodontic treatments[3]. Expansion therapy, specifically targeted at the arches, has become a central focus for managing this issue. Many patients with crowded teeth suffer from a mismatch between tooth size and arch length, a common type of malocclusion. [4]. Transverse mandibular deficiency is linked to characteristics like a reduced mandibular arch length, a constricted inter-canine width, crowding of the lower front teeth, and a posterior buccal crossbite.[5]. To address these issues, mandibular expansion is a key treatment approach, typically utilizing either methods of expansion which can be categorized as either active or passive[6]. Historically, various non-surgical devices, such as

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the Schwarz appliance, lingual arch, functional appliances, and archwires, have been utilized. While these methods achieved some degree of mandibular arch expansion, most of the observed changes were primarily due to tooth tilting rather than a true increase in the size of the mandibular bone. [7].

Biological Factors Influencing Bone Remodelling :

Biologics, which are related to an individual's age, body weight, and initial bone mass, play a significant role in bone remodelling[8]. In this context, preadolescent mandibles are often utilized in studies due to their high potential for bone remodelling[9]. Bone is a dynamic tissue that continuously remodels in response to external forces, regulated by various homeostatic mechanisms. Mechanical stimulation is a key environmental factor influencing bone, and Wolff's law explains this process[10]. According to Wolff's law, continuous mechanical loading prompts bone to alter its internal architecture and shape according to mathematical principles, leading to a phenomenon known as adaptive bone remodelling[11]. This process involves physiological changes in bone structure as it adjusts to a new biomechanical environment[12].

Mechanical Influence on Bone Structure:

Several factors influence how bone responds to mechanical load, including load direction, bone geometry, microarchitecture, density, and the contractions of surrounding muscles. [13]. This indicates that bone is an anisotropic material, with properties that change based on the direction of the applied forces [14]. Furthermore, the muscles attached to the surface of compact bone can greatly influence load intensity, playing a role in altering the bone's biomechanical properties.[15]. These factors collectively determine how bone adapts and remodels in response to external mechanical forces[16].

Challenges and Limitations of Traditional Mandibular Expansion Techniques:

Mandibular expansion poses more difficulties than maxillary expansion, primarily due to the absence of natural sutures in the mandible[17]. Unlike the maxilla, which can be expanded effectively through Rapid Maxillary Expansion (RME) that splits the mid-palatal suture, the mandible requires different methods to achieve transverse expansion[18]. Traditional techniques, such as those using appliances like Schwarz or lip bumpers, have led to only limited success in expanding the mandibular arch, with most results seen as dental tipping, not skeletal changes[19]. Consequently, these methods often fail to achieve true mandibular expansion[20]. Moreover, concerns regarding excessive dental expansion and proclination have resulted in compromised facial aesthetics and a weakened periodontium, reducing the appeal of these approaches. Therefore, true skeletal expansion of the mandible, especially without the need for surgical interventions, has remained an area of great interest but limited success.

Fabrication of Bihelix Appliance:

The fabrication of the Bihelix appliance begins with the adaptation of stainless steel bands onto the lower molars, followed by the taking of an alginate impression[21]. Once the impression is made, the bands are placed within it, and the mould is poured with dental stone to create a precise replica[22]. For the wire component, a 0.032″ or 0.036" round stainless steel wire is selected[23].

To begin the fabrication of the appliance, the depth of the lingual sulcus is measured, ensuring accurate placement of the appliance within the oral cavity. A lingual holding arch is then constructed, incorporating two helices with a diameter of 1.5mm on each side, positioned near the molar region on the lingual surface. Each helix features one arm extending perpendicular to the coil. A second perpendicular bend is made in each helix to position the appliance along the lingual surface of the molar band. These arms are then soldered to the molar band, with the arms extending towards the canine region on both sides of the arch. The arms of the Bihelix are carefully contoured to accommodate the existing crowding, ensuring a precise fit that will facilitate effective treatment.

Case over view with recreance to Figure 1-4

Activation and Adjustment of the Bihelix Appliance :

The Bihelix appliance can be pre-activated by spreading the two molar bands apart before cementation or activated afterward using three-prong pliers at the lingual bridge of the expander. [24]. In the cases described, activation was achieved through pre-activation of the appliance, with a 5-degree adjustment of the arms during each visit to gradually increase the appliance's expansion effect. Reactivation of the appliance was performed monthly, with the force progressively compounded during each adjustment.

Due to insufficient initial activation, a rolling-in effect of the molars was observed, which was subsequently corrected by further activation of the central portion of the lingual holding frame. The extent of movement varied from 3mm to 8mm over a period of 5months depending on the amount of activation done. The extent of movement achieved varied between the anterior and posterior regions. It is crucial to note that the amount, direction, and point of application of force are key factors in achieving effective arch expansion and tooth movement. Studies have demonstrated that in

appliances made from cobalt-chromium wire with a diameter of 0.9mm, an average movement of approximately 2mm was observed every 3 months, underscoring the significance of precise force application in achieving predictable outcomes in mandibular expansion[25].

Biomechanics of Mandibular Expansion Using the Bihelix Appliance :

Bone remodeling, a physiological process, plays a crucial role in expanding the mandible. When subjected to mechanical forces, bone undergoes two primary processes: modeling and remodeling. These biological mechanisms allow bone to adapt to changes in its mechanical environment. The mandibular bone, like any other bone, responds to mechanical loading, and with appropriate force application, can undergo significant structural changes, such as mandibular expansion. This review suggests that modifying the location and method of force application could improve the biomechanical response, resulting in more efficient mandibular expansion.

The Bihelix appliance represents a promising non-surgical solution to mandibular expansion. Unlike other expansion methods that primarily induce tooth inclination, the Bihelix appliance is designed to apply forces that lead to more true skeletal changes. This approach aims to encourage bone remodeling, resulting in actual skeletal expansion of the mandible. The appliance's design allows for a more controlled and gradual expansion, leading to changes in both the dental and skeletal components of the mandible. Animal studies, such as those conducted by Hamada et al., have shown that mandibular expansion can lead to changes in the alveolar bone, providing further evidence that skeletal expansion can be achieved with appropriate force application. These findings suggest that the Bihelix appliance, by promoting bone remodeling rather than merely altering tooth inclination, could offer a more effective means of achieving mandibular expansion.

Assessment of changes:

Arch widths near the canines, premolars, and molars were measured by identifying the maximum distance between the contact points on the proximal surfaces using a divider or vernier caliper. A study by Kenshi Aki et al. analyzed the morphological changes in the teeth and alveolar bone of patients who successfully underwent lateral expansion with the Bihelix appliance. The occlusal planes, defined by the bilateral molar lingual grooves, were bisected, and pre- and post-expansion tracings were compared. Expansion was categorized using Sekizaki's technique, with Type I indicating no effect on the apical base and Type II representing cases where measurement lines exhibited irregularities. [7].

Stability of Mandibular Expansion: Long-Term Outcomes :

A major concern with mandibular expansion is the potential for relapse, especially regarding the increase in intercanine width. Previous studies have highlighted that expansion in the intermolar and interpremolar regions tends to be more stable than expansion of the intercanine width. It is believed that relapse may occur due to pressures from the soft tissues, such as the lips and cheeks. However, studies have shown that these soft tissues adapt over time, reducing the pressures that can lead to relapse. Research by Shellhart et al. demonstrated that soft tissue pressures, which initially hindered stability, diminished as the tissues adapted[15]. Likewise, Boccaccio et al. proposed that the forces exerted by masticatory muscles, which can cause unwanted rotations during expansion, gradually diminish over time. This supports the notion that mandibular expansion can achieve stable results when properly managed. [13For instance, Gardner and Chaconas studied the dimensional stability of the mandibular arch in 103 cases and found that substantial intermolar expansion remained stable in non-extraction treatments.[12].

Fidan et al. also observed long-term stability with Trombone appliances, which apply labiolingual and transverse forces to expand the mandibular arch[32]. These studies support the notion that, while initial instability may occur due to forces from soft tissues and masticatory muscles, the stability of the expansion improves over time as these tissues adapt.

The Bihelix appliance has the potential to contribute to this stability, as it promotes gradual expansion that allows the soft tissues and muscles to adapt more effectively. As muscle and soft tissue adaptation progresses, the initial instability caused by these structures diminishes, resulting in a more stable outcome over time. Additionally, studies have shown that intermolar and interpremolar expansions, which the Bihelix appliance targets, are more stable compared to intercanine expansions, further suggesting that true skeletal expansion can be achieved with long-term stability.

Maximum Achievable Mandibular Expansion Using Arch Expanders:

The maximum mandibular arch expansion achievable with arch expanders varies based on factors such as patient age, appliance type, and the anatomy of the mandible[26]. In younger patients (pre-adolescents and adolescents), skeletal expansion is more feasible, with typical expansion ranging from 4 mm to 8 mm, especially with appliances like the Bihelix, which focuses on true skeletal expansion[27]. In adults, the rigid bone structure limits expansion to around 2

mm to 4 mm, often resulting in dental tipping rather than skeletal changes[28]. Appliances like the Schwarz may produce 4 mm to 6 mm of expansion, but with less skeletal involvement. Although transverse expansion in the mandible is more difficult than in the maxilla, skeletal expansion is favored for long-term stability, whereas dental tipping tends to be less stable. Rapid or excessive expansion, especially in the mandible, may lead to relapse due to the influence of soft tissue pressures.

Case Overview:

Case1:

Fig 1: Bihelix Appliance Installed with Initial Activation for Mandibular Expansion

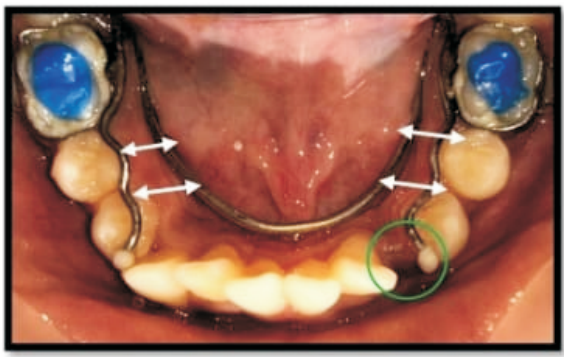

Fig 2: Bihelix Appliance Activation Showing Expansion Results at 3-Month Follow-Up

Case2:

Fig 3: Arch form pre-treatment with the Bihelix appliance: the foundation for optimal alignment and balanced occlusion.

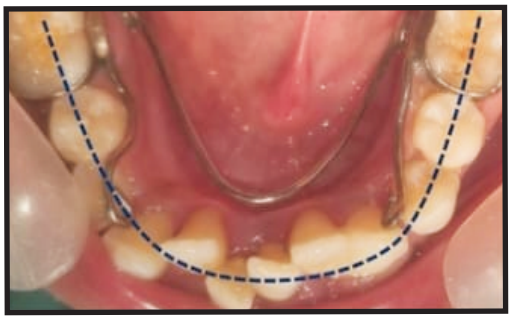

Fig 4: Significant arch expansion observed after 3 months of using the Bihelix appliance, demonstrating positive progress in dental alignment and bite correction

Conclusion:

Dental arch discrepancies or skeletal disharmonies affect approximately 1.5% of the general population, with fewer children impacted. This condition is often underreported, as it typically causes no visible facial changes in its early stages. However, it can disrupt the balance of the muscles involved in mandibular movement, leading to temporomandibular joint (TMJ) issues and other complications. According to Moss's functional matrix theory, the mandible, muscles, and TMJ are interrelated, and their growth is influenced by functional needs. Additionally, respiration plays a key role in shaping the craniomaxillofacial system. When the upper airway is obstructed, the body compensates, often resulting in mouth breathing, which can alter head, tongue, and hyoid bone posture. Mandibular expansion remains a complex challenge in orthodontics, but recent advances such as the use of the Bihelix appliance show promise in achieving true skeletal expansion [29]. While traditional methods often rely on dental inclination, the Bihelix appliance promotes remodeling of the mandibular bone, leading to more effective and lasting expansion[30]. Although concerns about relapse and soft tissue adaptation remain, studies indicate that gradual expansion techniques, like those offered by the Bihelix appliance, can lead to stable long-term outcomes. As the field of orthodontics continues to explore non-surgical solutions for mandibular expansion, the Bihelix appliance provides a valuable tool for managing crowding and transverse deficiencies in the mandible, offering patients an alternative to extraction or more invasive surgical procedures[31]. With ongoing research and refinement, the use of the Bihelix appliance could become a standard in non-surgical mandibular expansion, improving treatment outcomes for patients with mandibular crowding. Walter proposed that the mandibular arch width can be permanently expanded. In recent years, mandibular expansion has become increasingly common. Research has demonstrated significant increases in

dental arch width after expansion treatment, resulting in substantial crowding reduction and long-term stability. Today, screw-based mandibular expansion appliances are widely used, offering enhanced efficiency, hygiene, comfort, and minimal impact on speech.

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