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Role of retention in orthodontics: A narrative review

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Abstract

This narrative review summarizes the current understanding of the crucial role that orthodontic retention plays in maintaining the treatment outcome and preventing relapse. This summary gives background, purpose, key findings, and conclusions regarding the evolution, types, influencing factors, and duration of retention protocols. Further, recent advances in materials and digital technologies are discussed, together with their clinical implications for optimal long-term stability in orthodontic patients. However, long-term stability in orthodontics remains one of the biggest challenges, notwithstanding the fact that considerable advances have been achieved, and relapse is often reported. Individualized patient characteristics, including persistent periodontal tissue remodeling and changes in craniofacial growth, are critical determinants in this regard. The disorganization of periodontal fibers and newly laid bone subsequent to orthodontic tooth movement has not, so far, fully adapted to the altered configuration; thus, there is a tendency of teeth to move back to the pretreatment position. Therefore, posttreatment relapse is a persistent problem encountered by comprehensive orthodontic treatment, which raises the necessity of effective retention strategies. This review aims to fill the gap between scientific evidence and clinical practice by reviewing the current evidence and emerging trends in retention management. Specifically, it analyzes how different types, materials, and protocols of retainers influence treatment stability and compliance of the patient for the purpose of giving evidence-based clinical decisions. A deep understanding of the nature of retention, being multifactorial, is very important for both the orthodontist and the general dentist in designing an individualized retention protocol which takes into consideration the needs of each patient and biomechanical considerations.

Keywords: Orthodontic Relapse; Retention; Retainers; Stability; Treatment Outcomes

1. Introduction

Orthodontic retention is the period after active tooth movement that aims at maintaining corrected tooth position and prevents relapse into the original malocclusion [1]. This important phase of treatment is due to the inherent nature of teeth to relapse, essentially due to the re-organization of periodontal fibers, continued craniofacial growth, and muscle memory [2]. In fact, relapses are considered high as it occurs in about 70% to 90% of orthodontic cases and remains a persistent concern for the specialty [3]. This is explained by the multifactorial etiology of relapse including periodontal remodeling, muscular imbalance, and physiological changes connected with growth and aging, all of which should be taken into consideration when developing an effective retention strategy [4,5]. The phenomenon particularly depends on the elastic recoil of gingival fibers, as well as on the original malocclusion prior to treatment, all of which apply forces to the aligned teeth [6]. With a view to minimizing this tendency and stabilizing the outcomes of treatment, nearly all orthodontic patients are provided with retainers of one form or another [7]. The primary goal of retention, then, is to resist these forces and thus permit the long-term stability of the attained aesthetic and functional occlusion [8]. Because

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of its value in the maintenance of orthodontic corrections, a range of retention protocols have been proposed and their use has become part of modern orthodontic practice [4]. This includes not only a knowledge of the biomechanical processes responsible for relapse but also an appropriate choice of retainer type and compliance on the part of the patient if any long-term success is to be ensured [9]. This narrative review aims to critically analyze the multifunctional role that retention plays in orthodontics: its evolution over time, the methodologies involved, and its complex biologic and mechanical determinants.

2. Historical Background of Orthodontic Retention

Orthodontic retention has been considered to have undergone a noticeable evolution since the early part of the twentieth century-from the early preoccupation with purely mechanical stabilization to counter the immediate tendency for teeth to drift after treatment [10]. In many ways, early fixed retainers consisted mainly of arch-wires retained by ligatures and various forms of lingual retainers. They were designed to hold the dentition in a fixated position when early fixed devices did not have the capacity to account for physiological tooth position or incorporate longer-term biologic stabilization factors [11]. In some ways, this innovation lent greater flexibility and permitted better oral hygiene. Then compliance became the new enemy [8]. Continuous attempts appear to address a balance of effective system of stabilization on one hand and comfort to the patient and long-term biologic factors on the other. In fact, currently, a paradigm shift in the concept of retention is happening from purely mechanical restraint to more flexible and patient-friendly directed solutions [12]. This indicates a profound understanding of the biological events underlying post-treatment stability and the unique individual characteristics of each patient into the characterization of retention. In their early development, Angle and Case realized that even corrected malocclusions can have an inherent instability, and therefore, their retention protocols relied either on proactive long-term active appliances or some fixed bars [1]. Nevertheless, the crude early retainers provided the foundation for future improvements with an essential requirement for stability of teeth [13].

3. Types of Retainers

Orthodontic retainers are generally classified into materials which either remain inviolable or are removable. Each has advantages and drawbacks, with certain indications for their use [8]. Factors governing the choice between the two include patient preference, severity of initial malocclusion, and clinical judgment, with other contributory factors [14]. Moreover, fixed retainers bonded to the teeth work continuously irrespective of the co-operation of the patient and hence ensure better retention in the long term and specifically in maintaining the alignment of the mandibular incisors [15]. On the other hand, removable retainers like Hawley and vacuum-formed retainers might offer added advantages in oral hygiene and be modified to allow slight tooth movements. However, their success depends upon patient compliance [16]. Clinical practice often combines both fixed and removable retainers to realize the combined advantages of continuous stabilization and hygiene [17]. The dual approach attains ideal post-treatment stability while considering the variations in patient conformity and lifestyle [8]. The most commonly used removable retainers are the Hawley plate and the Essix splint [6]. The Hawley retainer, though esthetically unacceptable, is often indicated in a wide variety of clinical situations because of the simplicity of its fabrication and modification [6].

3.1. Fixed Retainers

The acrylic base and metal clasps used in its construction allow for customized fitting and support of the dental arches [18,8]. Fixed retainers, on the other hand, are usually bonded to the anterior teeth's lingual surfaces and can be further classified based on their material composition as multi-stranded stainless-steel wires, nickel-titanium wires, or fiber-reinforced composites [19]. These passive fixed retainers, which are designed for continuous retention, minimize the possibility of relapse as they prevent unintended tooth movements without necessitating compliance [20]. On the other hand, drawbacks like more critical oral hygiene and the possibility of wire fracture should be considered in recommending fixed retention [21]. Material selection for fixed retainers is essential since the durability and efficiency of a fixed retainer depend on the mechanical properties and biocompatibility of the selected wire or composite. For example, multi-stranded stainless-steel wires have durability and will not easily deform, while nickel-titanium wires offer better flexibility and spring-back properties that will adapt readily to minor physiological tooth movements [1]. Fiber-reinforced composites present an aesthetic option, but their mechanical properties and stability in the long term must be carefully considered [21]. Indeed, several comparative studies have indicated fixed lingual retainers present more stability regarding post-treatment changes than removable passive plates, considering the possibility of patient non-compliance [1]. On the contrary, it is also established that even the removal of fixed retainers after a long-term insertion can still create undesirable tooth movement [1].

3.2. Removable Retainers

Despite the development of more esthetic options, the Hawley retainer, as described by Charles Hawley more than a century ago, remains one of the most popular removable retainers, owing to its adjustability and durability [22]. Its design of a custom-fitted acrylic base and labial bow with adjustment loops enables minor occlusal settling and space closure in between the teeth while still allowing easy removal for eating and oral hygiene [9]. Vacuum-formed retainers are usually made of transparent thermoplastic material, which provides better esthetics and speech clarity compared with Hawley retainers, although they are typically less durable and less easy to adjust during active tooth movement [23]. The satisfaction of patients and the articulation of speech have also been reported to be superior with vacuum-formed retainers compared with Hawley retainers [24]. However, in a systematic review on the effectiveness of Hawley and vacuum-formed retainers in maintaining the position of the teeth, no difference was found in effectiveness, though with differences in patient compliance and preference [18]. On the other hand, some studies have noted that Hawley retainers allow for greater settling of the posterior occlusal contacts compared to full-coverage thermoplastic retainers, a highly desirable feature in an attempt to provide optimal intercuspation [25].

3.3. Vacuum-Formed Retainers

Vacuum-formed retainers, also called Essix retainers, are thermoformed with thin plastic sheets adapted precisely to the post-treatment dental arches, hence more aesthetically pleasing and less bulky than traditional Hawley retainers [26]. These transparent devices, resembling clear aligners that completely cover the dentition, provide a means of ensuring complete retention with almost total invisibility [24]. Unfortunately, some evidence shows that the use of Essix retainers may reduce occlusal contact during the retention period, thereby perhaps affecting posterior occlusal settling [6]. The uniform thickness of the material in an Essix retainer creates a physical barrier that prevents the full interdigitation between opposing teeth [6]. The hardness and elasticity of the material used in vacuum-formed retainers determine their long-term stability, as well as their wear characteristics that require replacement [27]. Options of different vacuum-formed retainers, as an example, polyethylene terephthalate glycol or polyethylene, are based upon desired properties regarding flexibility, durability, and cost.

4. Factors influencing retention

However, the longevity of such vacuum-formed retainers is also significantly influenced by patient habits, such as bruxism or clenching, which accelerate material degradation and may compromise their effectiveness in retention. Other than from material considerations, the major biological and growth-related influences upon maintaining the stability of orthodontic treatment outcomes are: Tendencies of Tooth Movement, Tissue Adaptation and Stability, and Patient Compliance and Adherence [28].

4.1. Biological and Growth-Related Factors

It also calls for an individual approach to retention, considering unpredictable late growth spurts that could undermine stability even for cases of apparently successful treatment outcomes. Genetic and epigenetic factors further complicate long-term predictions of occlusal stability, and the amount and direction of skeletal growth are influenced [1,29]. Such a basis of complex biological interactions provides the rationale for individual retention strategies based on one's unique growth potential and inherent susceptibility to relapse. For example, when mandibular growth is sustained well into post-adolescence, lower incisor crowding may result if not adequately managed with suitable retention strategies. Mesial drift and late crowding in the anterior are other dental arch changes unrelated to growth, further undermining post-treatment stability and pointing to the need for retention protocols in the long term [14]. Such inherent biological tendencies toward relapse, as manifested in post-retention crowding and incisor irregularity, are complicated interplays involving tissue memory, occlusal forces, and continuing craniofacial development [30,2].

4.2. Tissue Adaptation and Stability

Periodontal ligament and gingival fiber remodeling after orthodontic tooth movement is a critical biological process that determines long-term stability in the positions of teeth corrected by orthodontic treatment [31]. In more detail, the adaptation of collagen fibers, especially supracrestal ones, and the regeneration of the alveolar bone around the new position of the tooth are of great importance for a stable outcome after the treatment [32]. This may be an adaptive process that is usually slow and incomplete, contributing to the so-called "memory" when the teeth tend to move back toward their original positions [10]. Thus, the duration and type of retention have to be selected with consideration of the time needed for these tissues to make the necessary adaptations so that the orthodontic corrections will be adequately stabilized [13].

4.3. Tooth Movement Characteristics

Beyond the simple adaptation of biological tissue, there are inherent patterns of tooth movement, such as mesial drift, and developmental changes in intercanine and intermolar widths, which contribute significantly to post-treatment instability [33]. The inherent movements of the teeth, along with constant forces of mastication and maturational changes, ensure dental alignment is never in a truly static state but rather it is always dynamic [34]. Thus, the nature and magnitude of post-treatment tooth movements cannot be predicted with complete accuracy, which demands highly individualized retention protocols. This inherent unpredictability of post-treatment tooth movement is also complicated by the finding that arch length demonstrates consistent reduction following orthodontic treatment regardless of the initial treatment modality, including non-extraction and extraction protocols [35].

4.4. Patient Compliance and Adherence

For successful long-term retention, effective patient compliance with the protocols involving wearing removable retainers or maintaining fixed retainers is important since even slight non-compliance reduces the stability of the treatment results. More precisely, relapse of the teeth, possibly leading to supplementary orthodontic treatment, progresses with intermittent wear of removable appliances [4]. This is where the role of educating a patient and motivating him/her for retention regimens becomes important. Educating the patient at the beginning and in the course of orthodontic treatment is very important since full comprehension of the need for retention and potential relapse enhances compliance entirely [36].

5. Duration and Protocol of Retention

One of the longest debated issues in orthodontics has been the duration and type of retention, and there are advocates for indefinite retention because changes in the dentition occur throughout a lifetime, and the possibility of relapse does exist [9]. Most orthodontists now recommend retention for life; this may be especially indicated for today's trend of non-extraction treatments, which may inherently result in less stability following active treatment [37]. This view is reinforced by findings that even well-settled teeth that have undergone fixed retention may continue to move unintentionally, often requiring additional removable retainers [38,39].

5.1. Short-Term Retention Strategies

The common short-term retention protocols usually last for 6 to 12 months following the removal of appliances and provide better stabilization during the initial period of reorganization of tissues [40]. The important advantages of this period are the reorganization of the periodontal ligaments, the remodeling of the alveolar bone around the newly positioned teeth, and thereby minimizing the immediate relapse tendencies to a large extent [41]. Patients usually use either removable or fixed retainers during this period based on the specific malocclusion which was corrected and clinical judgment [42]. However, short-term retention can never effectively overcome the natural biological tendencies of relapse considering the fact that long-term maturational changes are well-documented throughout life.

5.2. Long-Term Retention Strategies

Long-term or even indefinite retention is being increasingly advocated to maintain treatment stability in view of the inherent potential for orthodontic relapse and continuing dental changes throughout life [4,43]. Such a philosophy recognizes that orthodontic corrections are subject to numerous influences on stability, irrespective of either the patient's age or the nature of the initial malocclusion [11]. Thus, the choice of an optimal long-term retention strategy has to be based not only on the type of malocclusion treated but also on individual patient risk factors related to relapse [16]. Finally, long-term stability has been reported in most studies to be closely related to the changes taking place within the first 3 to 12 months following active treatment, indicating the extreme importance of optimal retention during that period [44].

5.3. Evidence-Based Recommendations

Current evidence-based recommendations do, however, often advocate at least 12-24 months of full-time wear for removable retainers, followed by night-time wear indefinitely to minimize likely relapse [4]. On the contrary, long-term studies have shown that even fixed retainers, while largely effective, require regular follow-up and can be augmented with removable retainers, especially in the mandibular arch, to further ensure stability [39,1]. Such combined approaches aim to counteract the natural tendency of teeth to revert to their original positions, especially in situations where significant dental movements had been achieved during active treatment [45]. In addition, long-term studies that looked at outcomes as far away as 10 years beyond retention showed the longstanding nature of instability without continued intervention, even with fixed retention [46]. While actual stability defined by measures like the Peer

Assessment Rating can be strongly maintained for long periods of time after intervention like orthodontic treatment, some studies have documented stability as high as 79% a decade after active treatment [47].

6. Recent Developments in Retention Technology

Ongoing advancement in materials science and digital technologies has changed the design and manufacture of orthodontic retainers in order to deliver custom-made and effective solutions. This advancement aims to improve not only the aesthetics of the retention devices, but also their biomechanical utility in order to enhance patient compliance and long-term stability.

6.1. Novel Retainer Materials

Innovations included stronger and more esthetic thermoplastic polymers used in removable retainers, while bonding agents and composite resins were improved for fixed retainers. The new materials presented better adhesion and wear resistance. In addition, the newer generations of fixed retainers have often used multi-stranded or braided wires manufactured from nickel-titanium alloys that show excellent flexibility and resistance to fatigue when compared to the classical stainless-steel material. Thus, this allows minor physiological tooth movements to occur while maintaining tooth alignment [1]. These material improvements add to bonded retainers experiencing a reduced failure rate. This leads to the importance of planning for long-term predictable fixed retention [48]. Ceramic-filled polymers and fiber-reinforced composites exhibit improved mechanical properties and aesthetics. As a result, some patients will no longer be concerned about the visibility of retainers and potential discomfort [49]. Various investigators are also working on incorporating polymeric materials to improve post-orthodontic tooth stability by taking advantage of the wide range of biomedical application of these materials [3].

6.2. CAD/CAM and 3D Printed Retainers

CAD/CAM technology and 3D printing have, of course, added a great deal to making the fabrication of custom-fit retainers more precise and personalized for orthodontic retention appliances [4]. This digital workflow thus allows highly accurate retainers to be fabricated directly from intraoral scans or virtual models, reducing chair time and laboratory costs significantly [19]. For example, directly 3D-printed retainers represent an advantage over conventional materials due to their superior time and cost efficiency, with greater comfort and aesthetics for the patient [19]. This is also reflected in new materials currently being used, such as Co-Cr for minimal thickness and aesthetic organic polymers in labial wires, so as to improve comfort and appliance acceptance for the patient [50].The use of 3D printing allows retainers to be made with customized properties for the solution of various clinical issues, such as periodontal or aesthetic problems, by the proper selection of additive manufacturing materials [19].

6.3. Digital Monitoring and Assessment

This is now possible with the integration of digital monitoring tools, such as intraoral scanners and Artificial Intelligence-driven software, that allow tracking of tooth positions in real time and thus the early detection of relapse, which permits timely intervention and adjustment of retention protocols. These platforms are designed to study dental positioning changes very accurately and will detect small changes that might otherwise not be perceived until significant clinical relapse was observed [51]. These digital monitoring resources would enable both remote assessment and communication between the orthodontist and the patient in ways that would enhance patient engagement in their retention process.

7. Conclusion

In summary, the ongoing success of orthodontic treatment relies on precise retention considerations applied post-treatment and both the established literature and technological advancements, already being implemented to achieve successful treatment retention [52,53]. This review discusses the important principle of customized retention strategies in developing personalized retainers and utilizing digital monitoring to eliminate a biological tendency for relapse and prolong orthodontic treatment effects. Future work should future investigate how personalized approaches can be further optimized, particularly how to create individualized digitally fabricated retainers and AI-assisted monitoring to improve patient compliance and minimize the effects of relapse over time [54,55]. Continued research into new biomaterials with improved mechanical properties and biocompatibility for 3D printed retainers will enhance the field [56]. In the end, optimally developed retention plans will combine both patient specific biological feedback and adapted technology to improve orthodontic retention, while maximizing stability and prioritizing patient satisfaction [57]. In this way, orthodontic retention will evolve with patient specific conditions and technological advancements to minimize relapse and maximize success. Within that effort, integration of Artificial Intelligence into orthodontics may not only change the diagnostic and treatment planning phase, but also revolutionize the retention phase, by providing further precision into both monitoring and personalized intervention [58,59].

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed

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