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Review Article

Retention in Orthodontics: A review

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Abstract

Skeletal and dental correction obtained by orthodontic treatment may tend to return to the pre-treatment state. This condition is defined as relapse. The retention phase applied after treatment is important to obtain stable results. Periodontium, soft tissue pressures, growth and occlusion are among the factors affecting stability. In the last decade, interest in retention procedures has increased and it has been found that retention regimes differ from country to country. Although retention affects nearly every patient, there is minimal agreement on the most appropriate approach to be taken in an individual case. The many variations of the retention procedure, the introduction of different materials for retention, or individual patient factors are among the reasons that lead to difficulties in selecting retention protocols. Basic retention protocol is provided with removable and fixed retention appliances. For removable retention, hawley, wraparound, vacuum formed retention appliance and positioners are used. For fixed retention, rigid steel retention wire bonded to terminal teeth or flexible retention wires bonded to all teeth between 3-3 can be preferred. NiTi retention wires produced with CAD / CAM technology are also among the current materials. While fixed retention appliances do not require patient cooperation, periodontal follow-up is recommended. Patient cooperation is needed for the use of removable retention appliances, but easy cleaning of removable appliances is an advantage. 'Adjunct' procedures may also be applied to the teeth or surrounding periodontium to assist the retention process. For example, it involves reshaping teeth such as interproximal reduction or circumferential supracrestal fiberotomy. In this review, information about retention is discussed in the light of current literature.

Keywords: Orthodontic retention, orthodontic retainer, relapse, stability

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Introduction

Retention is an important stage of orthodontic treatment that can be defined as preserving the best possible aesthetic and functional position of teeth and skeletal relation (1). Appropriate retention protocols should be evaluated to prevent relapse after active orthodontic treatment and to ensure long-term stability of the obtained result. In 1934, Oppenheim defined retention as the biggest problem of orthodontic treatment (2).

Clinical and research consequences

1. Relapse and Retention

The need for retention after orthodontic treatment can be explained by several reasons (3).

- The gingiva and periodontium are responsible for relapse. After orthodontic appliances are removed, time is required for reorganization of the periodontium. Unlike the periodontal ligament, the gingival supracrestal fibers are not attached to the bone, and their remodeling speed is lower. It is known that reorganization of elastic supracrestal fibers may take up to 1 year after orthodontic appliances removal (3). Therefore, supracrestal fibers will cause relapse after orthodontic treatment (4). The fiberotomy procedure that can be performed to prevent relapse due to gingival fibers will be discussed later.

- Soft tissue pressures may cause movement of teeth that have unstable positions after treatment. It is preferred to adjust the occlusion in the zone where labial and lingual muscles are in balance. It is known that proclining the lower incisors and changing the arch form, which especially increase the intercanine distance, will affect the soft tissue pressure and increase the tendency to relapse (5). McClauey defended that the intermolar and intercanine distance should be maintained during treatment to avoid relapse (6). Tweed (7) indicated that the position of the mandibular incisors on the basal bone is important for stability, while Rogers (8) defended that balanced muscular function is important for stability. The patient's abnormal functions may also affect the treatment result negatively.

- Growth may affect the result after orthodontic treatment because intermaxillary relationships may tend to change, and this may cause changes in dentition.

2. Occlusion and Relapse

Kingsley indicated that occlusion is the most important factor for retention (9). Although today there is no consensus about the effects of interdigitation on stability, it is thought that large occlusal interferences may affect stability (5).

3. Third Molars and Stability

In orthodontic practice, it is a common concern that third molars may cause incisor crowding during their eruption. Studies on the effects of third molars show that there is minimal to no effect on crowding and relapse (10). Therefore, it is not necessary to remove third molars for the purpose of preventing relapse.

4. When do we need retention?

There are many retention protocols in orthodontic practice. It is important to know the retention requirement of the case for the clinician to plan a retention protocol.

Malocclusions that do not require retention (1, 11):

- Anterior crossbite: in the presence of sufficient overbite
- Posterior crossbite: in the situation wherein compact posterior occlusion is achieved (Skeletal expansion is not included.)

Conditions requiring permanent retention (1):

- Polidiastema closure
- Midline diastema closure
- Cases with severe rotated teeth
- Cases treated with mandibular dental expansion

5. Adjunctive procedures

Retention appliances and adjunctive procedures are used to prevent relapse. Circumferential supracrestal fiberotomy and interproximal reduction are in this group. Retention appliances will be discussed later.

5a. Circumferential Supracrestal Fiberotomy (CSF)

CSF is a surgical procedure that prevents relapse caused by elastic supracrestal fibers and was defined by Edwards in 1970 (12). The procedure is based on the principle of separating gingival fibers under local anesthesia with a scalpel. The main indication for the procedure is rotated teeth before treatment. Studies have shown that CSF is more successful in preventing rotational relapse (13). In the same study, patients who had CSF show less relapse at long-term follow-up compared to those who did not. The procedure is contraindicated for patients with active periodontal disease, inadequate attached gingiva, or poor oral hygiene. In the literature, it has been emphasized that as long as it is applied with the correct technique in carefully selected cases, this procedure does not cause periodontal damage (13, 14). It is possible to perform the CSF with laser, and patient comfort is better with this technique. It is as effective as the conventional

method in terms of preventing relapse, and also causes less pain and bleeding (15). The ideal timing for CSF is after the treatment because the area is more accessible after the appliances are removed and the gingival inflammation due to orthodontic appliances has decreased (14, 16). The papilla split method is an alternative to the CSF. This procedure is achieved by a vertical papillae cut at the buccal and lingual area of 1–2 mm just below the gingival margin in order to prevent rotational relapse (17). A papilla split is indicated in aesthetic areas since the risk of gingival recession is less than that for CSF, but the risk is very low in the CSF method as well (17).

5b. Interproximal Reduction (IPR)

IPR can be defined as reducing the mesiodistal dimension of the teeth by removing enamel from the contact points. IPR is a method of gaining space in orthodontic treatments and can be performed with strips, discs, and burs. It is a highly preferred method for correcting mandibular incisor crowding. During orthodontic treatment with IPR, teeth alignment consists of creating spaces through enamel reduction, and the tooth proclination is minimized. In addition, contact areas increase after IPR. These two conditions are thought to increase treatment stability (3, 16). It is also possible to use IPR in the debonding stage to provide retention in the anterior region of the mandibular arch (16). A randomized controlled study with a long-term follow-up shows that IPR applied to the mandibular anterior region at the debonding stage has similar effects on retention compared to other retention protocols (18). It is important to maintain the tooth morphology during IPR. If the related area cannot be reached, it may be necessary to first align the teeth.

The amount of enamel reduction is important in order not to cause tooth sensitivity and caries. A maximum of 0.5 mm reduction is recommended for each tooth, approximately 0.25 mm from one side of the tooth (19- 21). When evaluating the suitability for enamel reduction, tooth form should also be considered. Triangular-shaped teeth are more suitable than angular-shaped teeth in terms of providing space (20). To avoid iatrogenic damage, it is important to round the sharp areas and polish the enamel. It has been shown that there is no increased risk of tooth sensitivity, periodontal problems, and caries in patients who had IPR and have been followed up for a long time (22). Arman et al. reported that IPR procedures roughened the enamel surface significantly, but that the surface roughness was significantly reduced when polishing discs were used (23).

6. Retention Appliances (Retainers)

Retention appliances used after orthodontic treatment are divided into two groups as removable and fixed retainers.

7. Removable Retention Appliances

There are several reasons that removable retainers are preferred to fixed retainers. The first reason is that removable retainers can be used either full-time or part-time. They can be removed while tooth brushing, so that oral hygiene can be maintained easily. However, usage of the appliance depends on patient cooperation, and relapse is inevitable if it is not used as recommended (5). The most frequently used removable retainers are explained below.

7a. Hawley Retainer

The Hawley retainer was designed and first put into use in the 1920s (3). It is one of the most frequently used removable retainers. This appliance consists of a 0.7 mm stainless steel vestibule arch that contacts the labial surface of the anterior teeth, 0.7 mm Adams clasps attached to the molar teeth, and an acrylic plate (Fig. 1). It can be used combined with fixed retainers or alone. In the classic Hawley retainer, the vestibule arch is connected to the acrylic plate by bending it around the distal surfaces of the canines, but there are various modifications. In premolar extraction cases, the vestibule arch can be bent molar to molar to prevent occlusal force, which may cause extraction space opening (3). Thus, the appliance will maintain the arch length. The vestibule arch can also connect to the acrylic plate by bending from the distal surface of the lateral teeth. If an elastic material is used instead of wire in the front part of the Hawley, a more aesthetic appearance can be obtained, but it will be more difficult to control the incisor position with this method (24). In cases with tooth absence, an acrylic tooth can be added to the relevant area and used for space maintaining, and also for achieving an aesthetic result. The advantage of this appliance is that it does not prevent settling after treatment because the occlusal surfaces are open (25). After deep bite correction, the acrylic behind the upper incisors helps in maintaining the overbite (3). It can be preferred as a retention appliance for patients who have had maxillary expansion during treatment. Nighttime usage of the Hawley retainer is recommended (26).

Figure 1. Hawley Retainer

7b. Wraparound Retainer

The wraparound retainer is another frequently used removable retainer. It consists of a 0.7 mm stainless steel wire o from distal to distal of the molars, and it is connected to the acrylic (Fig. 2). Because the wire is one long piece, it can be deformed easier. Since the appliance does not cover the occlusal surface of teeth, it has a similar advantage to the Hawley in allowing vertical tooth movement and settling. A wraparound appliance is mainly used for maintaining space closure (3). There is no bended wire to prevent occlusion, and it is also satisfactory in preventing diastemas in extraction cases (1).

Figure 2. Wraparound Retainer

7c. Vacuum-Formed Retainer (VFR) (Essix)

The vacuum-formed retainer was first introduced in 1971 by Ponitz (27). This appliance is produced by adapting the thermoplastic material based on polyethylene or polypropylene polymer to the plaster under heat and vacuum and cutting 1–2 mm away from the gingival margin. Polyethylene-based materials can be bonded to acrylic and are considered more aesthetic since they are translucent (28). There are 0.75, 1, 1.5, and 2 mm thickness Essix materials available (Fig. 3). There are three main advantages of VFRs: their production is easier than that of other removable retainers, their cost is lower, and they are more acceptable to patients because of their transparency and thinness (29). The disadvantages of VFRs are that they are inadequate in the maintenance of deep bite cases, deformation and coloration can occur due to their usage, and they create thickness on the occlusal surface, especially when used in both arches (3). In addition, VFRs do not allow vertical movement at the posterior teeth, which is a drawback in cases wherein settling is needed. It is recommended that all teeth be included in an appliance in order not to cause excessive tooth eruption (30). Either full-time or part-time usage may be recommended to the patient. The retention requirements of the case and the performing of additional retention procedures are also important for the duration of usage. It is thought that the gradual reduction of usage at the end of a year will not cause increasing relapse (31). Thickett and Power compared the part-time and full-time use of VFRs in their study, and they found no significant difference on stability between the two methods (32).

Figure 3. Vacuum Formed Retainer

7d. Positioner

A positioner is an elastic retainer that covers the maxillary and mandibular arch together. It is generally used as a final appliance before debonding, and it can also be preferred as a retention appliance (Fig. 4). Positioners can be custom made or can come in prefabricated forms. The advantage of the positioner is that it successfully maintains the occlusal relationship and the position of the teeth in the opposing jaw (3). The disadvantage is that it is difficult to use due to its bulkiness. It can be preferred as a retainer, as it will create occlusal force in the posterior teeth after open bite treatments (33). For the same reason, it is not suitable for the maintenance of deep bite correction. In a long-term study, the positioner was compared with the VFR in the maxillary arch and with the fixed retainer and IPR in the mandibulary arch (18). It was concluded that the positioner may show less success on maintaining mandibular incisor alignment and maxillary intercanine distance compared to other methods in the long term, but it can be used as a retainer in permanent dentition.

Figure 4. Positioner

7e. Which removable retainer to choose?

Among the appliances mentioned, the Hawley and the VFR are the most preferred removable retainers in orthodontic practice. There are different opinions regarding which of the two appliances is superior. Patients may prefer VFRs since these appliances are more aesthetic, and clinicians may also prefer VFRs due to their cost effectiveness and ease of production (34). Patient comfort is also important because it encourages them to cooperate in using the appliance. Wan et al. compared the Hawley retainer and the VFR acoustically in their study, and although some voices were distorted in both groups, it was observed that pronunciation changed significantly in the Hawley group; however, speech improved significantly at the end of a month in both groups (35).

The effectiveness in preventing relapse is of primary importance for appliance selection. Rowland et al. in a randomized controlled study showed that VFRs are significantly superior to Hawley appliances when Little's irregularity index is evaluated, although there are no differences between the Hawley and VFR groups in terms of maintaining rotation, intercanine distance, and intermolar distance (36). This difference in Little's index is clinically significant in the mandibular arch but not in the maxillary arch. Mai et al. in a systematic review published in 2014 concluded that there were no differences between the Hawley retainer and the VFR in terms of maintaining intermolar-intercanine distance (37).

VFRs are thought to be more successful in controlling rotational relapse compared to the Hawley appliance (38). If one of the goals after orthodontic treatment is to allow vertical movement of the posterior teeth, the choice can be made for the Hawley or wraparound appliance. If settling is desired, it was recommended to prefer the Hawley appliance instead of the VFR, but it was stated that if the desired occlusion was achieved, both appliances would be sufficient to maintain the occlusal relationship (39). In a study that compares the wraparound appliance and the VFR, changes in occlusal contact surfaces and occlusal forces with time are not significantly different between the two groups (40). Hichens et al. reported more appliance breaking in the Hawley group than in the VFR group (34). Sun et al. stated that the lifetimes of the two appliances were similar (41).

8. Fixed retention appliances (Fixed retainers)

Fixed retention appliances are often preferred because they eliminate the issue of patient cooperation. Fixed retainers are applied to the lingual-palatinal surface of teeth and do not cause negative effects on smile aesthetics. Fixed retainers might pose a greater risk for plaque accumulation than removable retainers (42). After a fixed retainer is applied, the patient should be informed by the clinician on oral hygiene and called for controls regularly. By taking these measures, inadvertent tooth movement caused by wire breaking or deformation can be minimized. Fixed retainers should be applied precisely because adhesive systems are used, and retainer wire needs passive bending. The clinical complications associated with fixed retention appliances will be discussed later. As mentioned earlier, some orthodontic problems require long-term or permanent retention after treatment. In these cases, fixed retention appliances can be preferred, as the issue of patient cooperation is eliminated.

Fixed retention indications (5, 43):

- Midline diastema and polydiastema treatments
- Corrected severe tooth rotation
- Space maintenance before prosthodontic rehabilitation
- Mandibular incisor positions in sagittal plane are significantly changed
- Having received treatment of operated cleft lip and palate cases with severe scar
- Impacted tooth treatments
- Reduced periodontal tissue support
- Lip posture is not improved after increased overjet treatments
- Compromised occlusion

8a. Fixed retention methods

Different materials have been used for fixed retention up to the present day. Now, fixed retention is mainly provided with rigid stainless steel retainer

wire (Fig. 5) bonded only to terminal teeth and flexible multi-stranded retainer wire (Fig. 6) bonded to all teeth in the relevant area (43). For rigid retention wire bonded to canines, a round stainless-steel wire with a 0.7 mm diameter is preferred (44). Flexible or dead wires of various diameters, in round or rectangular cross section, consisting of 3 to 8 strands, and with coaxial, braided, or twisted forms are used for the type of fixed retention that is bonded to all teeth (45, 46). Nickel-free rectangular titanium retainer wire is also used in orthodontic practice (Fig. 7).

Figure 5. Canine to canine rigid stainless-steel retainer

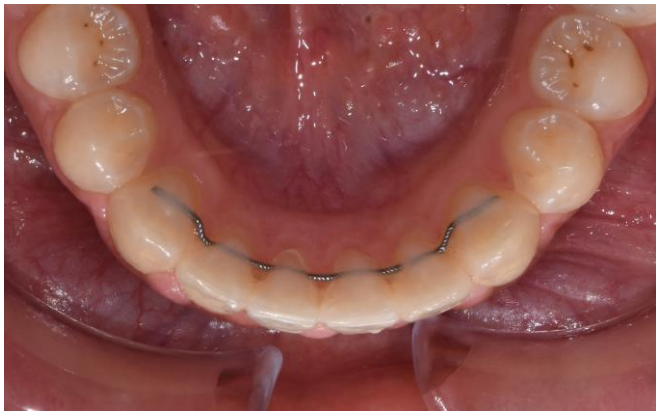

Figure 6. Flexible multi-stranded retainer

Figure 7. Nickel-free rectangular titanium retainer (0.027x 0.011 inch)

Flexible multi-stranded retainer wire bonded to the six anterior teeth was suggested by Zachrisson in 1982, and the indications were explained as follows (47):

- Anterior diastema closure, including midline diastema
- Rotated maxillary incisor treatment
- Adult patients who have tendency of tooth migration after orthodontic treatment
- Mandibular incisor extraction cases
- Having received space closure treatment of traumatic maxillary tooth loss
- Having received treatment of palatally impacted canine

Lee explained the indications of rigid stainless-steel retainers bonded to terminal teeth as follows (44):

- Cases with severe incisor crowding
- Cases for which lower intercanine distance is increased with treatment
- Cases for which lower incisors are proclined with treatment
- Non-extraction cases with mild crowding
- Maintenance of deep bite correction

The use of a flexible retainer wire, which is bonded to all six teeth, is recommended if there is a risk of independent movement of teeth, and a rigid retainer wire bonded to terminal teeth is recommended if mandibular incisors are proclined with orthodontic treatment (45). Although rigid retainer wire between canines is successful in maintaining the intercanine distance, it might be insufficient to control incisor movements (48). An in vitro study compared the deformation and tensile strengths of 0.0215 inch (0.546 mm) five-stranded wire (first group), 0.016 × 0.022 inch (0.41 × 0.56 mm) eight-stranded dead braided wire (second group), and 0.0195 inch (0.495 mm) dead coaxial wire (third group). The deformations of the dead wires in the second and third groups were significantly higher, while the tensile strength of the five-stranded wire in the first group was better (46). Zachrisson recommended 0.0215 inch (0.546 mm) five-stranded stainless-steel wire for fixed retention in routine (49). As a result of the Cochrane review that was published in 2016, it was concluded that there is not enough evidence as to which retention protocol or material is more successful (50). In a long-term follow up study published in 2017, a rigid stainless-steel retainer bonded to canines and a 0.0195 inch (0.495 mm) twistflex retainer were compared, showing that there was no significant difference between the two groups in terms of relapse, and that they were both effective during the retention period (51). Gunay and Oz in their study applied 0.0175 inch (0.444 mm) six-

stranded stainless-steel wire with the indirect method and 0.0195 inch (0.495 mm) coaxial dead soft wire with the direct method to patients and showed that there was no significant difference between the two groups in terms of bonding failure, but mandibular crowding increased, and intercanine distance decreased more significantly in the second group using dead wire (52).

Custom-made nickel titanium retainer wire fabricated with CAD-CAM technology is among the current fixed retention materials used in clinical practice. The retainer is designed in accordance with the tooth morphologies and occlusion in the digital model obtained by scanning the polyvinyl siloxane impression taken from the lower and upper arches of the patients or by intraoral scanning, and it is produced by cutting the NiTi leaves. It is thought that with the optimal tooth adaptation provided by the customized production of CAD-CAM NiTi retainers, inadvertent tooth movements and failures due to occlusal interference can be prevented (53) (Fig. 8). As a result of a study in which NiTi retainers produced by CAD-CAM technology were applied to patients, intraoral retainer positions were found to be similar to the planned location, and this may be advantageous in the presence of limited space and difficult anatomical structures (54). As an alternative to metal fixed retainer materials, resin fiber strips have also been among the fixed retention procedures, but their clinical applications have been limited due to their prevention of the physiological tooth movement and their long-term failure rates (55).

Figure 8. CAD-CAM NiTi retainer

8b. Direct and indirect methods for fixed retention

Bearn suggested that the fixed retainers should be bent on a plaster model to optimize tooth surface adaptation, and he stated that the retainer can be bonded with direct or indirect methods (45). In the indirect method, a silicone guide is used to adapt the bended wire to the teeth and bond it in the correct position. In the study, by comparing the effects of direct and indirect methods on bonding failure in fixed retainers, it was shown that there is no difference between the two methods (56).

8c. Dual retention protocol / Fixed versus removable retention

The dual retention option, in which fixed and removable retention protocols are used together in the same dental arch, can be considered. The advantage of dual retention is that if a problem occurs in the fixed retention appliance, the removable retainer can be effective in preventing relapse until it is resolved (43). There are different opinions regarding the superiority of removable and fixed retention protocols when compared to each other. Al-Moghrabi et al. reported that fixed retainers are more successful in preventing crowding, especially in the mandibular anterior region, compared to the removable retainers (57). In a recent randomized controlled study, VFRs and fixed retainers bonded to canines were compared, and no significant difference was found between the two groups in terms of their contribution to stability (31).

8d. Fixed retainers and failure

Relapse may occur as a result of debonding the wire from the tooth surface, and this situation occurs in two ways. In the first case, separation occurs between the enamel and the composite surface depending on the possible isolation problem during the application, while in the second case, the separation occurs between the composite and the wire surface due to insufficient or worn adhesive (58). When a canine-to-canine rigid retainer wire is used, patients can notice the problem more quickly, and they may apply to the clinic. Retainers that are not sufficiently passive during the application and wire breakage or wire distortion due to occlusal forces may cause inadvertent tooth movement or alveolar bone defects (3, 59). Flexible multi-stranded wires may cause such complications if they are not applied carefully (60). Dead soft wires are not activated like flexible wires, but they may cause inadvertent tooth movement due to wire deformation during breakage (59). There are many different opinions about the failure rates of fixed retainers. However, it is known that extending the retainer up to the canines, especially in the maxillary arch, increases failure risk, and therefore it is recommended to apply a maxillary retainer to four incisor teeth (49).

9. Periodontal health and retention protocols

Oral hygiene can more easily be maintained with removable retention appliances (48). There is a question whether fixed retention appliances create a tendency for plaque accumulation and periodontal disease. In a study, patient groups with VFRs and fixed retainers were compared, and there was no significant difference in gingival inflammation reported between the groups (57). Compared to VFRs, fixed retainers

may cause more plaque accumulation, but the thought is that this does not have a clinically significant effect on periodontal health (61). In a study comparing the effects of 0.015 inch (0.38 mm) multi-stranded flexible wire and 0.036 inch (0.91 mm) round rigid stainless-steel wire on periodontal health and stability, it was seen that multi-stranded wire caused more plaque accumulation, but it was more successful in achieving stability (62). It is thought that CAD-CAM NiTi retainers will have a positive effect on periodontal health, and further researches are needed (63). According to a systematic review published in 2020, it is reported that fixed retainers do not cause significant damage to the periodontium, but additional studies are needed (64).

Conclusions

Since relapse is one of the biggest problems in orthodontics, the retention phase is very important. When choosing the retention protocol, patients' initial malocclusion, periodontal health, and cooperation should be evaluated. While using removable retention appliances, the patients should be encouraged to cooperate, and should be informed that if they do not comply with the recommendations, relapse will occur (5). Regarding fixed retention appliances, it is crucial that the patient has regular check-ups to prevent complications that may occur. Further studies are required due to the lack of information on currently applied techniques in the literature and the lack of consensus on the subject of retention.

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