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Original Article

Assessment of the Effectiveness of Two Different Orthodontic Retention Protocols

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Abstract

Introduction: The main goal of orthodontic retention is to keep the teeth in their corrected positions. Fixed or removable retainers are the most common types of retainers used during the retention phase. For the maxilla, various types of retainers have been described, including the vacuum-formed retainers and Hawley retainers. Fixed retainers are used for the lower jaw.

Aim: The aim of the present study was to assess the retention characteristics of Hawley retainers, vacuum-formed retainers, and fixed retainers in preserving dental arch dimensions and tooth alignment.

Materials and methods: Seventy subjects were examined and distributed into two retention groups. One of the groups received maxillary Hawley retainers and bonded retainers in the mandible. The other group received maxillary vacuum-formed retainers and bonded retainers in the mandible. The mean retention period was two years. Maxillary and mandibular casts were analyzed at pretreatment, debonding, and two years in retention. The assessed measurements were the arch length, intercanine width, interpremolar width, intermolar width and Little's irregularity index.

Results: Vacuum-formed retainers maintained maxillary anterior teeth alignment more effectively than Hawley retainers did. No differences in transversal dimensions were found between the two retention protocols. Hawley retainers showed superior retention characteristics in maxillary arch length preservation compared to vacuum-formed retainers. Even with bonded retainers, relapse could still happen. All measured variables showed a tendency to relapse to the pretreatment values in the two groups.

Conclusions: Vacuum-formed retainer maintained maxillary incisor position more effectively than Hawley retainers did. No differences were observed in the transversal dimensions between the two groups. A greater decrease in the mandibular intermolar width was measured between T1 and T2 in both groups where bonded retainers were used.

Keywords

bonded retainers, Hawley retainer, irregularity index, retention, vacuum-formed retainer

INTRODUCTION

The problem of orthodontic retention and stability is well over a century-old. A primary aim of orthodontic therapy is to stabilize the obtained corrections, which makes retention an important phase of orthodontic treatment.

Long-term follow-up of treated patients often reveals an increased trend to relapse. A number of studies have demonstrated that relapse is observed in almost 70% of cases after completion of orthodontic therapy.[1,2]

The exact etiology of relapse is not known, and most studies show that crowding relapse appears to be multifac-

torial.[3-5] Various factors could be linked to the orthodontic relapse after orthodontic treatment, the most important of which being changes in the late ages of craniofacial development[6], and the post-treatment reorganization of the periodontal ligament and gingival and elastic[7]. Therefore, it is not possible to presume which cases will remain stable and which cases will experience relapse.[8]

Misaligned mandibular incisors in particular are most prone to relapse. Crowding of lower incisors in the post retention phase is a sign of orthodontic instability.[9] In order to prevent the relapse, it is a common practice to implement retention following the orthodontic therapy. For that purpose, removable retentive appliances such as Hawley retainers (HRs) and/or vacuum-formed retainers (VFRs) are used. Different types of removable or bonded retainers for permanent or semi-permanent retention are used to prevent mandibular incisors' relapse.

Prescription of retainer is based on the characteristics of the pretreatment malocclusion and clinicians' views and preferences.[10,11] A systematic review concluded that there was no uniform retention approach that could avoid relapse and that more research was needed to provide evidence for optimal retention.[12] Further research on the effectiveness of the different retentive devices is needed to resolve the problems in this respect.

AIM

The study aimed to assess the retention characteristics of Hawley retainers and VFRs in the maxilla and fixed retainers in the mandible.

MATERIALS AND METHODS

Orthodontic plaster models of 70 subjects (aged between 11 and 23 years) were analyzed. The study involved patients who had undergone non-extraction orthodontic therapy with a fixed appliances (straight-wire technique, 0.022 slot). All patients were treated by postgraduate students enrolled in a three-year post-graduate residency program at the Orthodontic Department in the Faculty of Dental Medicine in Plovdiv, Bulgaria.

The inclusion criteria in the study were the following:

1. Non-extraction orthodontic treatment
2. Fixed appliance treatment involving both arches
3. No previous orthodontic treatment
4. Complete permanent dentition

The exclusion criteria were the following:

Hypodontia in the anterior or posterior segments of the dental arch

1. Supernumerary teeth
2. Severe skeletal deformities requiring combined orthodontic-surgical treatment
3. Single-arch or sectional fixed appliance treatment

The two investigated retention protocols included the following retention appliances:

1. In the maxilla – a removable Hawley retainer (HR) and a fixed canine-to-canine in the lower arch (HR-FR group).
2. In the mandible – a removable vacuum-formed retainer (VFR) and a fixed canine-to-canine in the lower arch (VFR-FR group).

Removable retainers were used full time for the first 6 months and then only at night-time for the next 18 months. The mean retention duration was 2 years.

Patients were divided into two different groups. One of the groups, the HR-FR group, consisted of 35 patients. HRs were fabricated according to the original requirements.[13] This retainer was fabricated with Adams clasps on first molars, a labial bow with U-loops on the canines and an acrylic base plate **(Fig. 1)**.

The other study group, the VFR-FR group, included 35 patients. VFRs were fabricated according to the requirements by 1 mm polyvinyl siloxane sheets, covering all occlusal teeth surfaces[14] **(Fig. 2)**.

The mandibular retainer was the same in both groups – a fixed retainer fabricated from 0.0195-in Twistflex wire, bonded to all six anterior teeth with Transbond LC (3M Unitek) **(Fig. 3)**.

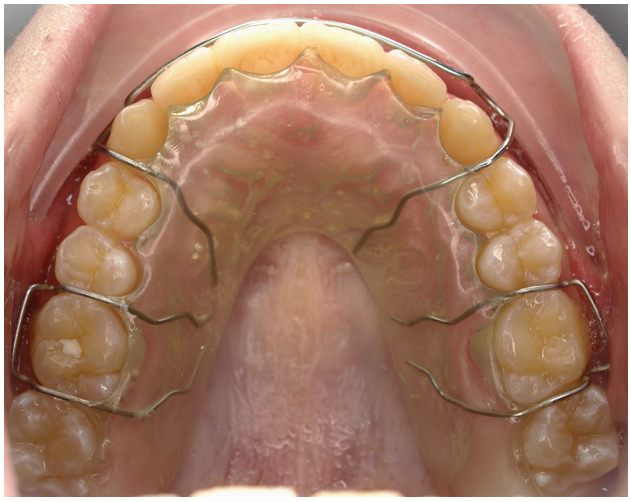

Figure 1. Hawley retainer.

Figure 2. Vacuum-formed retainer.

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Figure 3. Mandibular fixed retainer.

The removable retainers were delivered to the patients within 24 to 48 hours after the braces removal. Cast models' records were analyzed at three different time periods: pretreatment (T0), post-treatment (T1), and the follow-up at 2 years (T2).

All measurements on the cast models were taken with a digital caliper (TWIN-CAL TESA (IP40 150 SQ, 0.01-mm precision). The measured variables were dental arch length, Little's irregularity index (LII), interpremolar width, intermolar width, and intercanine width **(Fig. 4)**.

Little's irregularity index was used to assess the crowding in maxillary and mandibular anterior segments.[9] The irregularity index was calculated based on the linear anatomical contact points of displacements of maxillary and mandibular frontal teeth. The sum of the discrepancies is the value of the index and the deviations are measured on a scale from 0 to 10+. The following intervals were used to interpret the irregularity in anterior segment according to the Little's index: >6.5 mm – severe irregularity, ≥3.5–6.5 mm – moderate irregularity, 1–3.5 mm – mild irregularity, and 0 mm – perfect alignment.[9] We used LII because of its great reproducibility and precision.

Intercanine width (CC): the distance between the deepest points at the gingival margins of the permanent canine crowns[15] **(Fig. 4)**.

Interpremolar width (PP): the distance between the buccal cusp tips of the premolars.

Intermolar width (MM): the distance between mesiobuccal cusp tips of the first permanent molars.

Arch length (L): the distance between the mesial contact points of the first permanent molars and the contact points of the central incisors[16] **(Fig. 5)**.

Statistical analysis

The studied parameters are continuous values measured in millimeters, therefore, this was checked for by means of the Shapiro-Wilk test. For correct choice of statistical methods, continuous values were checked for normality of the distribution by the Kolmogorov-Smirnov test. In case of presence of a normal distribution, parametric statistical methods were applied. In case of violations in the requirements for normal distribution or in case of data measured on dichotomous, nominal, and ordinal scales, we used non-parametric statistical analyses. The intergroup measurements were compared with an independent samples *t*-test. The analysis of the data was performed using IBM SPSS, ver. 26 (2018) and the specialized program for medical analysis MedCalc, version 19 (2018).

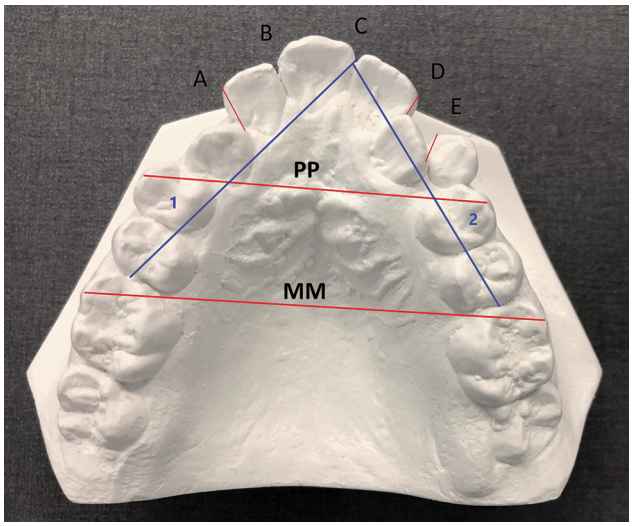

Figure 4. Dental casts measurements: LII (A+B+C+D+E), intercanine width (CC).

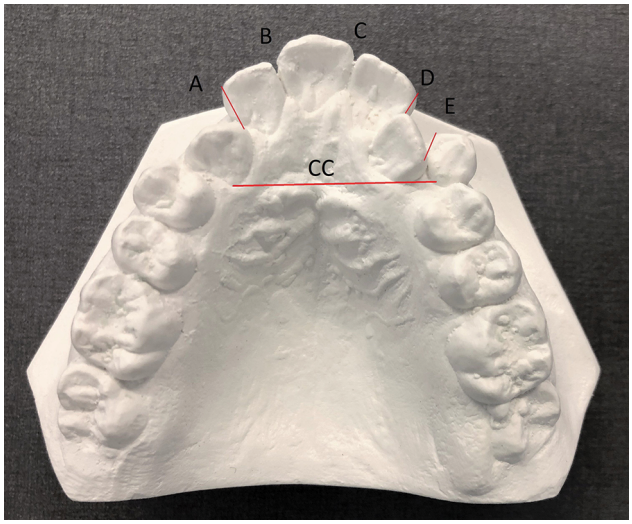

Figure 5. Dental casts measurements: LII (A+B+C+D+E), intermolar width (MM), interpremolar width (PP), arch length (L) (1+2).

RESULTS

The mean age of the patients in the first group (HR-FR) was 14±3.15 years (range, 10.75–23 years). The study group included 12 (34%) men and 23 (66%) women, with a significantly higher proportion of women (p=0.016). The mean age of male and female patients was similar (13.16±3.37

years and 14.46±3.01, respectively), with no significant difference (p=0.253).

The mean age of the patients in the second group (VFR-FR) was 16.28±6.49 years (range, 12.25–26.75 years). Sex distribution showed a significantly higher relative share of women – 69% (n=24) compared to men – 31% (n=11) (p=0.004). The mean age according to the sex of the patients was very similar: men – 16±5.32 years, women 16.41±7.06 years, with no significant difference between them (p=0.863). **Table 1** shows the demographic data.

The first group of patients (HR-FR) had a lower mean age than that of the patients in the second group (VFR-FR), but the differences failed to reach statistical significance **(Table 1)**. The retention period in the VFR-FR group was shorter compared to HR-FR group, but without significant difference.

Table 2 shows the changes in the standard deviation and the mean deviation of arch width in the two groups at pretreatment period, postretament period, and 2 years retention period.

At post-treatment time, the irregularity index in maxilla in the HR-FR group decreased by an average of −10.52±4.69 mm and by −7.66±5.68 mm in the VFR-FR group. The intergroup differences reached statistical significance (p=0.025). At the end of year 2, the irregularity index in the upper arch was significantly higher in the HR group (3.53±2.72 mm) compared to that of the VFR group (0.95±1.22 mm).

In the mandible, after the active phase of orthodontic treatment, the irregularity decreased by similar amount in both groups (p=0.932). At T2, the mean relapse was higher in the HR group (+2.13±2.30 mm) compared to VFR group

Table 1. Mean age and mean retention duration of subjects in the Hawley retainer group and VFR group

Parameters	HR-FR $\bar{X}$±SD	VFR-FR $\bar{X}$±SD	*P*
Age at T0	14.02±3.15	16.28±6.49	0.070
Age at T1	16.50±3.13	18.82±6.96	0.078
Age at T2	18.92±3.62	20.59±6.93	0.214
Duration of retention period	2.25±1.28	1.76±0.93	0.074

Table 2. Changes in the Little's index of irregularity, interpremolar width, intermolar width, intercanine width, and arch length for the HR-FR and VFR-FR groups in upper and lower dental arch at T0, T1, and T2

Measurements	HR-FR $\bar{X}$±SD	VFR-FR $\bar{X}$±SD	*P*
LII upper jaw change at T1	−10.52±4.69	7.66±5.68	0.025*
LII lower jaw change at T2	3.53±2.72	0.95±1.22	0.000**
LII lower jaw change at T1	−6.73±4.85	−6.83±4.95	0.932
LII lower jaw change at T2	2.13±2.30	1.03±1.71	0.027*
PP upper jaw change at T1	4.03±2.60	2.87±2.72	0.075
PP upper jaw change at T2	−0.28±1.22	−0.34±0.55	0.815
PP lower jaw change at T1	3.00±3.06	1.44±2.66	0.026*
PP lower jaw change at T2	−0.32±1.19	−0.31±1.09	0.971
MM upper jaw change at T1	1.18±2.53	0.90±2.16	0.608
MM upper jaw change at T2	0.44±1.40	-0.36±0.69	
MM lower jaw change at T1	1.48±2.75	1.36±2.01	0.836
MM lower jaw change at T2	−0.86±1.62	−0.60±0.99	0.421
CC upper jaw change at T1	1.71±5.02	0.36±2.85	0.172
CC upper jaw change at T2	−0.32±1.65	−0.32±0.92	1.000
CC lower jaw change at T1	1.50±1.42	1.00±1.88	0.214
CC lower jaw change at T2	−0.12±0.97	−0.51±0.92	0.089
L upper jaw change at T1	1.87±5.07	−1.28±5.96	0.020*
L upper jaw change at T2	0.10±0.90	−0.42±0.99	0.025*
L lower jaw change at T1	2.37±2.95	1.09±4.22	0.147
L lower jaw change at T2	−0.36±1.40	−0.89±2.33	0.253

(1.03±1.71 mm) **(Table 2)**. In both groups, the observed irregularity in the lower anterior area was greater than that in the maxillary anterior area.

There were no differences in the interpremolar width in both arches between the two study groups over the retention period. The analysis revealed insignificant difference in the upper intermolar width between the study groups but showed reduction in lower intermolar width (−0.86 in HR group and −0.60 in VFR group) **(Table 2)**.

Significant differences were found in the upper and lower intercanine dimensions in the Hawley retainer group and VFR group between post-treatment and 2 years of retention. While maxillary and mandibular intercanine widths remained stable in the first group, the second group showed reduction of intercanine width over the retention period (−0.32 mm in maxilla and 0.51 mm in mandible).

The majority of examined patients in the HR group demonstrated an increase in arch length in the upper jaw at the end of the orthodontic therapy. Conversely, in the VFR group arch length decreased significantly. The same trend persisted until the end of year 2 of retention. At T2, a slight but significant reduction in the arch length was found in both arches in the VFR-FR group.

DISCUSSION

We found that the VFRs maintain the maxillary incisor alignment more effectively than Hawley retainers do. The better stability of maxillary incisors in VFR group is associated with the better retainer grip, whereas Hawley retainers have a point contact on the vestibular tooth surface that allows the teeth to move.[14] Moreover, patients show more cooperation to wear VFRs than Hawley retainers because of the esthetics of VFRs.[11] This result confirms the results obtained by other authors.[17-19]

Mandibular arch irregularity tends to increase with time even with bonded retainer.[20] In the current study, LII in the lower arch increased in both groups; however, the HR-FR group showed significantly greater mandibular irregularity than the VFR-FR group because of the higher initial incisor irregularity in the first group. The high irregularity values may be explained with active wire elastic deformation during bonding or mastication.[21,22]

The increase in the irregularity index during retention could be attributed to the normal age-related changes.[23]

In this study, both maxillary interpremolar and intermolar widths in the two patient groups revealed minimal changes over the retention period. Between T1 and T2 in both groups in mandible, where bonded retainers were used, a greater intermolar width decrease was observed. However, the change was more distinct in the first group than in the second group. This can be accounted for by the different amount of expansion achieved in both arches. As a result of the treatment, the MM in the VFR-FR group increased by 0.9 mm in the maxilla and 1.36 mm in the mandible. The achieved expansion in the HR-FR group was 1.18 mm for the upper and 1.48 mm for the lower jaw. Overexpansion and change in the arch perimeter during treatment, especially in the lower dental arch are risk factors for relapse.[24] Therefore, mandibular molar width in HR group exhibited a greater tendency to decrease in the retention period.

The mean intercanine width was reduced during the study period in both groups. The intercanine reduction was more prominent in VFR-FR group. It should be noted that the reduction was less than 0.5 mm. The post-treatment changes were small and can be considered clinically insignificant. Our data do support results from another study that VFRs and HRs are effective in maintaining intercanine arch width.[17]

Many studies support the concept that arch length has a tendency to revert to the values before treatment.[1,25] The arch lengths in the maxilla and mandible increased during treatment in the HR-FR group and remained stable throughout the retention period. In contrast, the arch length in the VFR-FR group remained almost unchanged during treatment, but after retention, there was a statistically significant reduction in both arches. A significant difference was detected in the maxilla on comparing the arch length between the groups. The arch length was considerably reduced in the VFR group compared with that of the HR group. These results suggest that HRs maintain maxillary arch length more effectively than VFRs do. These results are in contrast to some other findings.[18]

CONCLUSIONS

Vacuum-formed retainers provide better stability of maxillary anterior teeth position than Hawley retainers do. No differences in transversal dimensions were found between the two retention regimes. HRs are more efficient than VFRs in preserving the maxillary arch length. Even with bonded retainers, relapse can still happen. All measured variables showed a tendency to relapse to the pretreatment values in the two groups.

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Оценка эффективности двух различных протоколов ортодонтической ретенции

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Резюме

Введение: Основной целью ортодонтической ретенции является удержание зубов в исправленном положении. Несъёмные или съёмные фиксаторы являются наиболее распространёнными типами фиксаторов, используемых на этапе ретенции. Для верхней челюсти описаны различные типы ретейнеров, включая ретейнеры вакуумной формовки и ретейнеры Hawley. Несъёмные ретейнеры используются для нижней челюсти.

Цель: Целью настоящего исследования было оценить ретенционные характеристики ретейнеров Hawley, вакуум-формованных ретейнеров и несъёмных ретейнеров при сохранении размеров зубной дуги и выравнивания зубов.

Материалы и методы: Было обследовано 70 человек, которые были разделены на две ретенционные группы. Одна из групп получила верхнечелюстные фиксаторы Hawley и приклеенные фиксаторы на нижнюю челюсть. Другой группе были установлены вакуумно-формованные фиксаторы на верхнюю челюсть и наклеенные фиксаторы на нижнюю челюсть. Средний срок ретенции составил два года. Модели верхней и нижней челюсти были проанализированы до обработки, снятия брекетов и по истечении двух лет ретенции. Оценивались такие параметры, как длина дуги, ширина межклыкового промежутка, межпремолярная ширина, межмолярная ширина и индекс неравномерности Little.

Результаты: Вакуумные ретейнеры более эффективно поддерживали выравнивание передних зубов верхней челюсти, чем ретейнеры Hawley. Различий в поперечных размерах между двумя протоколами ретенции обнаружено не было. Ретейнеры Hawley продемонстрировали превосходные ретенционные характеристики при сохранении длины дуги верхней челюсти по сравнению с ретейнерами вакуумной формовки. Даже с фиксированными ретейнерами возможен рецидив. Все измеренные переменные показали тенденцию к возврату к значениям до лечения в двух группах.

Заключение: Вакуумный ретейнер сохранял положение резцов верхней челюсти более эффективно, чем ретейнеры Hawley. Различий в поперечных размерах между двумя группами не наблюдалось. Большее уменьшение межмолярной ширины нижней челюсти было измерено между T1 и T2 в обеих группах, где использовались ретейнеры.

Ключевые слова

несъёмные ретейнеры, ретейнер Hawley, индекс иррегулярности, ретенция, вакуумформованный ретейнер